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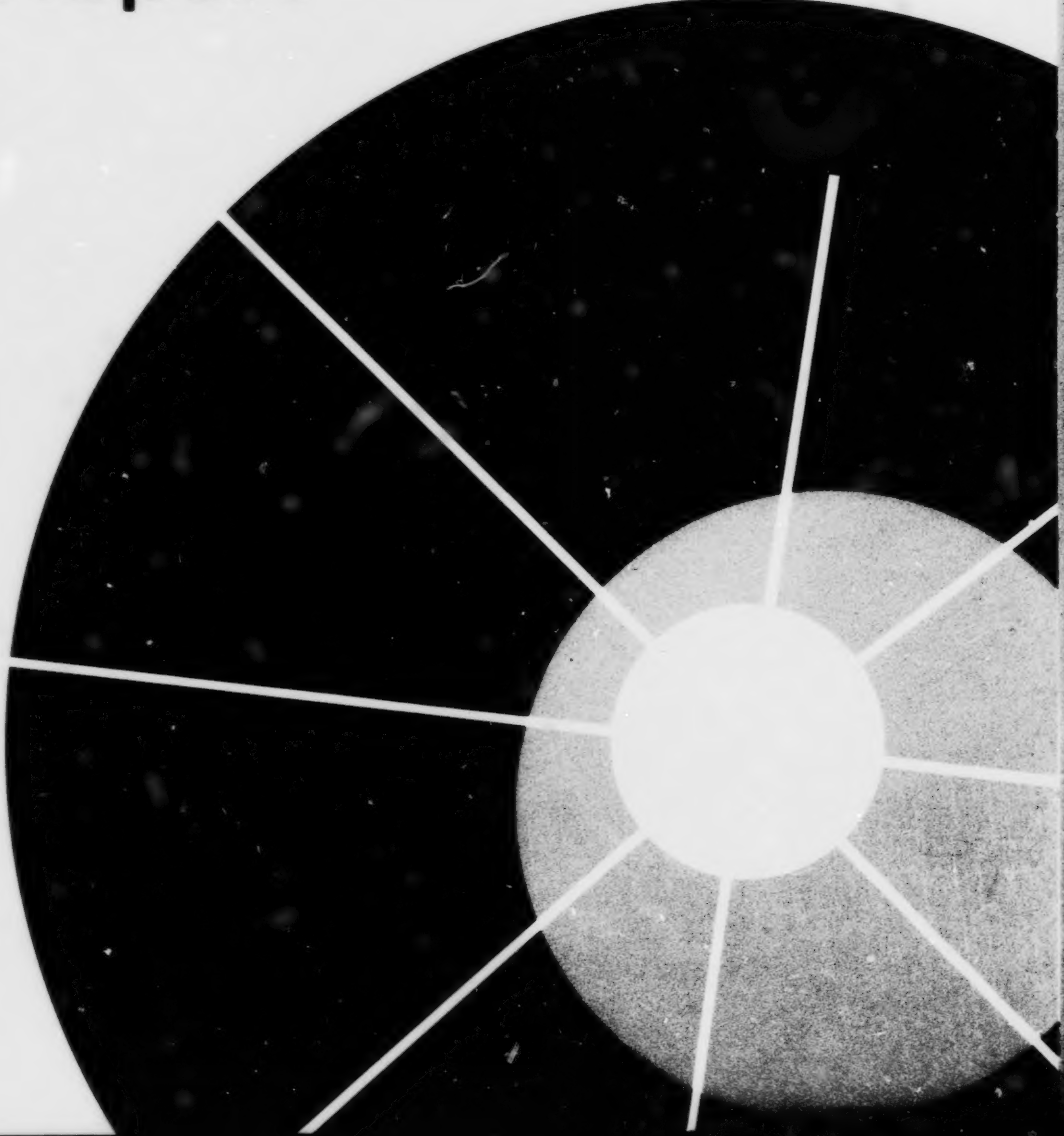
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



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CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient;
- To create employment in new or existing industries;
- To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

However, neither the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, nor the Government of Canada as represented by Energy, Mines and Resources Canada, accept liability for any errors, omissions, or inaccuracies that may; be included in or derived from this report, nor do they assume any liability with respect to the use of, or actions resulting from the use of, any information contained in this report.

Farm Energy Management Program

Phase II

Phase Two Report
on a Renewables-Conservation Demonstration Program Project

Conducted By
The Saskatchewan Research Council
Saskatoon, Saskatchewan

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Project Leader: Ewen Coxworth

Miscellaneous
Report FP-21

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We particularly thank the more than 21 farm families involved for hospitality and cooperation on the visits which we made to each of these farms.

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CHAPTER 1

INTRODUCTION AND SUMMARY

E. Coxworth

This is the report of the second year of the Farm Energy Management Program. The work this year has taken us well into the project. This have been done both from the standpoint of determining where energy (fuel, fertilizer, fuel oil) is being used on each farm, but also from the standpoint of evaluating various energy conservation measures farmers have already done, and in working with the farmers to initiate other energy conservation activities.

Throughout the year it was becoming evident that measures taken to improve the efficiency of the use of fuel and fertilizer were frequently interlocked with other equally vital farming concerns. For example:

- cropping systems to give better protection of soils.
- better use of field equipment.
- testing and using new technology, e.g. air photos to determine how to place fertilizer at different rates based on varying soil fertility within a field.

There seem to be two types of activities leading to improved efficiency of use of energy:

1. Small, 'housekeeping-type' of measures; frequently low cost, relatively easy to do and applicable to many farms: Caulking and weather stripping doors and windows to reduce heat losses in homes, or painting fuel tanks silver to reduce rates of evaporation loss, are examples of such small savings. As one chapter in this report indicates, the sum total of such measures could lead to several thousand dollars worth of savings on typical farms. Interviews with the farmers involved in this

project has shown that most farmers have already put in place many of these measures.

2. New farm practises, particularly cropping systems, which lead to more efficient use of energy, e.g. fuel and fertilizer: These changes are generally more costly, more site specific, more complicated, and will take longer to put in effect.

Examples include:

- snow management to increase yields by using available moisture more effectively, thus producing more crop for the same investment in fuel.
- minimum tillage to reduce fuel use and give greater soil protection.
- use of legume green manure crops like sweet clover to provide some of the nitrogen fertilizer needs and increase soil organic matter.

Some farmers are already testing these techniques. Others are actively considering initiating a particular practise.

The seminar held in November of 1982 seems to have been helpful in bringing farmers together to hear of each others experiences in both types of energy saving activities, and in having both farmers and agricultural research scientists describe new techniques which are beginning to transform farming in western Canada. A bulletin in being prepared summarizing the seminar.

Specific chapters in this report describe the following:

Chapter 2. Total energy use on the 21 farms in 1982. This is reported in both total dollars and energy. Comparisons are made with 1981 and 1980.

Liquid fuel use for all farm powered equipment and for each major type of use was measured using fuel tank meters and log sheets. Fuel tank meters were installed on all the farms in the spring of 1982. Work is still in progress on evaluating the mass of data (5800 items) obtained, in reconciling certain discrepancies, and in analyzing and interpreting the data in different ways. A complete separate report is planned for later in 1983. In this progress report we give an example of data obtained for one farm, and some examples of ways the data can be analyzed. Based on reviews of this data that have been held with individual farmers, it appears that this sort of information can be of considerable use both to farmers and to policy makers. We plan to run simulations of the amount and type of fuel savings that might be achieved on each farm in the future.

Presentation of results is as follows:

Year II Progress Report

- Bar charts comparing 1980, 1981, and 1982 energy use by fuel
  - cost ($)
  - energy content (GJ)

In the complete report (later in 1983) will be given:

- Energy use related to farmed area and to production.
  - GJ per cultivated ha (acre)
  - GJ per cropped ha (acre)
  - GJ per unit of production

  analyses of each farm and a summary table for all 21 farms.
- Pie diagrams comparing energy use distribution
  - 1981 distribution, estimated by farmer
  - 1982 distribution, based partially on fuel matter logs (April to December), partially on reported total energy use for 1982.

  one chart per farm

- Bar charts comparing 1980, 1981 and 1982 energy use by fuel
  - cost ($)
  - energy content (GJ)

  } one chart per farm

As mentioned previously, fuel meters were installed on all fuel tanks on each farm, and records were kept by the farmer for all powered equipment and for each type of operation (e.g. seeding, summerfallowing, harvesting, hauling grain).

A section of chapter 2 describes the installation of the fuel meters, problems and trouble shooting, farmers' experience with recording fuel use, and an example of a fuel log.

A further section gives presentation of results

Year II Progress Report (this report) gives the following, using farm 3 as an example:

i - 1982 fuel use vs time.

ii - 1982 fuel use by job type (eg. seeding)

iii - 1982 fuel use by machine, with rate of fuel use, where available.

The complete report, later in 1983, will analyze fuel use per cultivated acre, tonne of wheat, etc.

Chapter 3. Discussions were held with the participating farmers to evaluate the many small conservation changes that could be made, to find out how many had been done, and reasons for making changes, or not making changes.

This chapter describes the general results of these discussions and summarizes findings.

A number of small energy savings appear to be possible on many farms.

In total these could add up to several thousand dollars per average farm. A booklet itemizing and referencing these measures was prepared on a separate contract. The opportunity was taken to test the practicality and adoption of these measures in this project on the basis of interviews with most of the farmers. Chapter 3 gives an outline of these measures, gives examples, and results of interviews with the participating farmers. Most farmers in the group have already put many of these conservation measures into practise.

We believe this is an important finding. The results of the evaluation of these 21 farmers, in terms of which small energy conservation measures are practical and easy to put into place, and which others need to be improved or changed, could be very useful in extension work with other farmers who have not yet tested these techniques.

Gear up-throttle down techniques to save tractor fuel are being planned to be tested on several farms in 1983 as part of a collaboration with studies of Professor Zoerb, Agricultural Engineering Department, University of Saskatchewan.

Chapter 4. Major changes in farm practises and cropping systems leading to improved energy efficiency.

From discussions with individual farmers, and general comments at the seminar in November, 1982, it appears that major changes are starting to happen in western Canadian agriculture.

Some of these changes are:

- snow management
- minimum tillage
- greater use of legume green manure crops

To which might be added (within the project):

- applying different rates of fertilizer to different areas of a particular field (see separate report by R. Bens)

- use of aerial photos to interpret farm practises and plan changes (see chapter 5)

- use of mini-computers to help assess the effect of major changes, and to help plan the change over (section of chapter 4 by R. Bens).

We are analyzing the dollar and energy efficiency results of several experiments carried out on innovative cropping systems such as were described at the seminar held in November, 1982:

4.1 A research experiment to test deep banding of fertilizer and chemical fallow, either alone or in combination, was carried out on the farm of one of the members of the program. Our analysis of the results shows the costs, income, and yields resulting from these methods, compared to conventional mechanical tillage, with or without fertilizer. This experiment was designed and carried out by K. Foster of the Crop Development Centre, University of Saskatchewan. Initial results are presented in Chapter 4.

4.2 One of us (M.G.) had the opportunity to assess how many of a class of Voc Ag students (i.e. new farmers) were starting or planning to start new croppings system. A considerable number are making changes. Results are summarized in the second section of this chapter.

4.3 The income and dollar and energy costs associated with growing winter wheat "stubbled-in" are being analyzed based on data on farmers results (non-project farmers). B. Fowler of the Crop Development Centre has provided considerable assistance in collecting and interpreting the results. These results are to be completed by June of 1983 so as to be presented at a winter wheat symposium.

4.4 The dollar and energy results of using sweet clover as a green manure or dessicated cover crop are described, based on experiments carried out by L. McLean of the Crop Science Department, University of Saskatchewan. These results are to be completed by June of 1983.

4.5 Snow management studies are underway on several farms as part of Farm Lab. Our plan is to measure the energy efficiency effects based on 1983 yield data.

4.6 On rolling cultivated land, knoll tops frequently need more fertilizer than do hollows or lower slopes. This concept was analyzed by R. Bens on his farm in the Biggar area. The yield effect of placing more fertilizer on knolls and less (or none) in hollows was measured. The initial results indicate a marked improvement in net income and a much more even yield over the field by applying this technique. This experiment is described in a separate report by R. Bens.

4.7 Making major changes in farming practises involves many complex factors and decisions. To aid in planning such changes and in assessing their effects, a micro-computer program was developed. It is being evaluated with farmers. A complete separate report is planned in year 3.

Chapter 5. Air photos were taken of each farm in 1982. The possible uses of air photos for improving the efficiency of farm operations is described in this chapter. Examples include - changing methods of working fields, - considering draining small sloughs and consolidating water in a few more permanent water bodies for irrigation or aquaculture use, - planning specific fertilization rates for eroded knolls (variable rate of fertilizer application). This chapter also describes the use of computers and map plotters to work out better ways to use a particular field on one farm, as an example of what can be done.

Chapter 6. New conservation acticities planned for year 3. A considerable number of new actions are planned for year 3. These are summarized in this chapter.

Oil prices and future changes in farming

In the last few months world oil prices have fallen. Hopefully this may give farmers some relief from the cost-price squeeze of the last years, in that price increases in Canada may be less rapid, or delayed more than was forecast a year ago in our year 1 report. One of the principal reasons cited by many energy experts for the fall in oil prices is the success of energy conservation. Up to 2/3's of the price fall may be due to this cause. Thus even when we pull out of the recession, many of the gains in net income may still be retained. The second generation of energy savings, caused by more major innovations, ranging from gear up-throttle down, through the new cropping practises being adopted in western Canada, seem to have the potential to further improve farm net income and act as a further brake on run away increases in energy prices. Many industries seem to be finding that adoption of new and improved techniques and processes has the potential to reduce energy costs and improve income. Many of the innovations in agriculture may be done primarily for reasons other than energy savings: they may make more efficient use of water, fertilizer, and/or farm machinery; they may increase yield; they may provide better protection of soils. Nonetheless they frequently also make more efficient use of energy. Thus their adoption may provide a further damping effect on energy price increases as a very important side benefit.

CHAPTER 2

ANALYSIS OF ENERGY USE

H. Boerma[1], M. Gimby[2] and W. Gamble[2]

INTRODUCTION

In order to evaluate the work which was completed in Year 2 of the Farm Energy Management Program (FEMP), it is useful to review the major objectives of the program as stated in the Year 1 Report.

The overall objectives of the farm energy management program are:

1. To measure the energy use at the present time on 21 cooperating farms in terms of:
   a) where energy is used and in what amount: e.g. gasoline, diesel fuel, heating oil, electricity, fertilizer.
   b) the time of the year when various forms of fuel are used, e.g. when are the peaks in diesel fuel use?
   c) with liquid fuels, to further subdivide fuel use down to specific unit operations: e.g. discing, harrowing, baling hay, grinding feed grains, hauling grain, etc., in order to identify the relative magnitude of different fuel uses, and as an aid to considering the importance of various conservation measures.

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[1] Data assembly, computer analysis and presentation.

[2] Data collection, fuel meter installation and trouble shooting.

Acknowledgement: L. Reid wrote the computer programs for analyzing the fuel log data.

2. To aid in measuring energy use, and in testing the effectiveness (cost, dollars and energy saved, payback times) of various conservation techniques, we need to do the following things:
   a) provide suitable record keeping books for each liquid fuel end use (each truck car, tractor).
   b) install fuel meters on all farm fuel storage tanks, including slip tanks used for field re-fueling.
   c) test, evaluate and then install fuel monitors on major gasoline using equipment on each farm: private cars, half ton trucks and perhaps on some gasoline using field equipment (e.g. tractors, combines) to:
      i) provide a check on record keeping books
      ii) to test the effectiveness of instant feedback monitors in reducing fuel consumption.
      iii) to test the cost effectiveness of such on board monitors
      iv) to provide more accurate fuel consumption data than from the record books based on the "filling the tank" approach.

   d) for diesel equipment (mainly large tractors and big trucks) monitors are more costly and need more testing. The plan is to purchase several types, have them evaluated by research groups (for example, the Agricultural Engineering and Crop Science Departments, University of Saskatchewan, and the Agriculture Engineering Group, Agriculture Canada, Swift Current Station). Based on these initial results (provided results come fast enough), we would plan to purchase perhaps one diesel monitor per farm to be installed on a large tractor, to measure fuel use per unit operation, and test various energy-saving options (e.g. gear up-throttle down).

e) electrical meters would be installed to distinguish between various electrical energy types: e.g., hog barns (fans, heaters, and lights), home, machine shop, farmstead, irrigation pumps.

Some of these objectives were found to unattainable, namely:

1. c) It was found that the data supplied by the farmer-cooperators was not detailed enough for analyzing fuel use by unit operations (discing, harrowing, baling hay, etc.). Instead, fuel use was broken down by groups of operations, as shown in Table 2.1. (page 18).

2. c) Several available on-board gasoline fuel flow meters were reviewed and a selected model was tested on a Saskatchewan Research Council-owned vehicle. It performed poorly and, therefore, a decision was made not to equip gasoline powered vehicles and production equipment with such meters.

d) On board diesel fuel monitors were difficult to obtain. Three monitors were obtained recently (April, 1983) and are now being installed. These will be evaluated this year before deciding if more use of these in future projects is recommended.

e) In the spring of 1982, the Saskatchewan Power Corporation (SPC) agreed to take on responsibility for the analysis of electric energy use on the 21 farms. This decision was reversed later in the year. However, at that time, SPC made available to the FEMP a number of kilowatt hour-meters for such an analysis. Unfortunately, due to lack of time, and taking into account the secondary importance of electric energy use as compared to liquid fuel use on the farms, no work on this part of the program has been performed todate.

With these exceptions, work to achieve the program objectives proceeded as planned as described below.

It may be useful, in planning future studies in Saskatchewan or elsewhere, to point out here that the project team worked with 31 farms, spread out all over Saskatchewan's farmed area and an average of 150-200 km away from the team's base in Saskatoon. This has restricted the number of farm visits possible within the project's budget and has created considerable difficulties and delays in obtaining complete and reliable information.

FARM FUEL METERING

Installation and Evaluation of Fuel Tank Meters

Gravity flow meters were used on farm fuel tanks for measuring fuel use per field operation. Three different sized meters where required for the farms:

NUMBER	SIZE
78	3/4"
3	1 1/2"
1	2"

Two 3/4" meters, the Gasboy and the Fillrite were looked at for possible use in the program. Tests conducted by O. Olm (SRC), showed both meters to have almost equal performance in terms of measuring a given volume of liquid. We chose to use the Fillrite because the register on this meter would display a maximum of 999 litres, whereas the register on the Gasboy would display only 99 litres, which was less than many farmers would require when fueling their tractors. For the three farmers requiring meters for 1 1/2" flow, the Gasboy was chosen because of availability and service. One farm required a meter for 2" flow and we were able to acquire a used meter.

The meters were installed in April 1982, either by the farmers themselves, or in some cases by the FEMP* research team. These were attached both to the stationary fuel tanks in the farm yard and on the slip tanks in the 1/2 tons which were used for filling equipment in the field. Along with each meter a log sheet was assigned (see page 16). This log was printed on water proof paper and protected by an aluminum clip board with cover. In most cases the clip board was attached right on the fuel tank stand for easy access (a pencil and sharpener were attached to the clip board). This log was to be filled in after fueling each piece of equipment.

In nearly all cases, farmers accepted the concept of keeping track of where their fuel went with considerable interest. A few of the farmers were concerned about the time that would be required to fill out the logs but most of these adapted to the record keeping system quite well.

Some examples of positive feedbacks from the farmers include:

- all of the cooperators indicated that the meters gave them a better idea of where the fuel went and how much different operations required.

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* FEMP = Farm Energy Management Program

- a few of the farmers mentioned that they were attempting to use the meters as a conservation tool, i.e. measuring fuel use before and after a change in field operations (cultivating deeper or changing gears and throttle speed)
- one farmer in the program with two identical tractors and impliments was using the meters to see which of his men could get the best fuel economy (he offered a bonus incentive to the winner!).

Problems encountered

- In three cases the meters failed to function properly and had to be repaired or replaced.
- A few of the farmers complained that the meters slowed down fuel flow and increased fueling time. (They found this particularly bothersome during the busy season).
- According to factory specifications, a flow greater than 4 g.p.m. is required for the Fillrite meter to measure fuel flow accurately. In some cases where the storage tank is very low, the flow was less than 4 g.p.m. and the meters would not function properly. For, the 1983 season, farmers having the above mentioned problems have agreed to either raise their tanks, use electric pumps, or use a larger hose and nozzle to increase fuel flow.

Data Collection

The farm fuel metering part of the FEMP involves measuring and recording the volumes of liquid fuel (diesel fuel and gasoline) used by each piece of production and transportation equipment for specific operations. Record keeping started at the end of April 1982 and will be continued at least until the end of 1983.

The hardware allowing the farmer to keep track of this is described elsewhere in this report (see preceeding pages). In summary, it consists of:

- a dispensing dual-register fuel meter on each farm fuel storage tank and on each slip tank used for refuelling in the field. One register is reset to zero at the start of each equipment fuelling operation and registers the volume of fuel added to the on-board tank. The other register accumulates the total volume of fuel dispensed from the storage tank;
- a log sheet at each fuel storage tank;
- an on-board use meter (hour meter; odometer) with a register showing the accumulated use of the equipment in hours, kilometres or miles.

At each fuelling operation, the farmer records on the log sheet the following set of data: day; month; equipment identification; use meter (register) reading; volume of fuel added to the on-board tank; accumulated fuel dispensed from the tank; and the operation(s) for which the equipment was used since its' on-board fuel tank was filled last. This set of data is referred to as a "record". The records are being analyzed by calendar year.

The log sheets of twenty farms for the period May to December, 1982, were available for analysis for this report. They yielded a total of approximately 5800 records. The log sheets for farm 18 were lost in the mail.

FUEL LOG SHEET

FARM ____________________ FUEL TANK ____________________

Date	Vehicle or Machine	Hours or mi or km	Litres	Accumulated Litres	Jobs done Last Tank		General Comments
					Job	Hrs or km	

Data Standardization and Storage

The log sheets for the twenty farms were marked up by the project team with brief codes indicating the groups of operations performed, according to the breakdown provided in Table 2.1.

The 5800 records were then entered in a computer file. Considerable effort was required to standardize these records for computer analysis.

Apart from the inevitable errors made during data entry, the following problems were encountered with the data as found on the log sheets:

- identification of the same piece of equipment by different names;
- operations for which equipment was used recorded only some of the time;
- use meter readings recorded only some of the time;
- a small number of simple mistakes (obviously wrong date or use meter reading).

The first two of these problems were resolved through consultation with the farmer.

The third problem was resolved for some pieces of equipment by interpolating missing use meter readings where this was judged to be appropriate. For other pieces of equipment not enough use meter readings were available to provide any meaningful results and all such readings were set to zero.

The fourth problem was corrected by changing obviously erroneous records so as to eliminate inconsistencies.

TABLE 2.1

FARM FUEL LOG SHEET

CATEGORIES

CROP:	
S:	SEEDING: Includes seedbed preparation, fertilizer application, hauling of seed and fertilizer, and seeding.
SWC:	SUMMERFALLOW & WEED CONTROL: Includes summerfallow (cultivate, rodweed, etc.), spraying and water hauling for spraying, and avadex and treflan application. (Where avadex was applied during seeding and was difficult to separate, it was included in seeding).
H:	HARVEST AND HAULING: Includes swathing, combining, augering, hauling, drying and storage.
LI:	LAND IMPROVEMENT: Rock and root picking, bush clearing, draining, filling washouts, etc.
FS:	FARMSTEAD: Mowing, painting, pressure washing, etc.
CM:	CROP MISC: Flax straw burning, etc.
VEHICLES:	
T:	TRANSPORTATION: Where vehicles were not used for hauling grain, feed, etc., "Transportation" was used.
LIVESTOCK:	
F:	FEED: Cutting, conditioning, baling, ensiling, hauling, and feeding.
M:	MANURE: Manure handling
LM:	LIVESTOCK MISCELLANEOUS: i.e. Pounding posts, backrubber oil, etc.
ITEMS WHICH SHOULD BE NOTED:	
R:	RECREATION: Boat or skidoo.
C:	CUSTOM: Where the farmer did custom work for someone else.

An example of how the records are stored in the computer's Fuel Log file follows:

Column: 1	2	3	4	5	6	7	8
05/11/82	1	d	8440	1174	1176	swc	319
06/05/82	1	d	case	0	0	m	65

where: column 1 contains: date (day/month/year)

column 2 contains: farm number

column 3 contains: fuel type (d = diesel fuel)

column 4 contains: equipment identification code (see next text table).

column 5 contains: use meter (hour meter; odometer) reading at previous fuelling operation (0 = "no reading").

column 7 contains: operation performed last (see Table 2.1 for explanation of code).

column 8 contains: volume of fuel taken on (litres)

Three other computer files were created: an Equipment Identification file; an Operations file; and a Fuel Type file.

The Equipment Identification file contains a full equipment description for each of the equipment identification codes used in the Fuel Log record file, as well as the unit of its use meter register (h = hour; km = kilometre; mi = mile). An example of records stored in the Equipment Identification file is:

Column:	1	2	3	4
	1	8440	Tractor, John Deere 8440, 1980	h
	1	case	Skidsteer loader, Case 1845	h

where: column 1 contains: farm number

column 2 contains: equipment identification code

column 3 contains: equipment description

column 4 contains: use meter unit

The Operations file contains short descriptions of each of the operations codes used in the Fuel Log record file, such as:

Column:	1	2
	swc	Summerfallow and weed control
	s	Seeding

where: column 1 contains: operations code

column 2 contains: short description of group of operations

The detailed description of the groups of operations is shown in Table 2.1.

The Fuel Type file contains only two records:

Column:	1	2
	d	Diesel fuel
	g	Gasoline

The system of computer files described above provides a flexible data base which makes it easy to add, delete or change fuel log records, equipment, equipment descriptions, operations, operations descriptions and alternative fuels. The system could be used for the analysis of liquid fuel use of any farm [and could be adapted easily to provide a data base for analysing the use of energy commodities with similar use patterns in other industries].

Data Manipulation and Report Creation

Computer programs were written to manipulate the fuel log record data and to create a number of reports. Sample reports, referred to below, are provided in the Appendices to this report. It should be noted that these sample reports are based, for most farms, on data taken from the log sheets for the period May to December, 1982. They do not usually include off-farm purchases and, fuel-use in the period January to April, 1982. These reports should therefore be considered as preliminary. Further work is in progress to arrive at a fuel use profile for the whole year.

First, the records were sorted by farm number, by fuel type, by equipment, by operation and by date, to create the Farm Fuel Log Detail Report (Appendix A, A-2 to A-8). The report is preceeded by a Farm Fuel Log Legend (Appendix A, A-1), explaining the abbreviations used. The Farm Fuel Log Detail Report also shows the fuel use rate (in litres per hour (L/h) and Imperial gallons per hour (gph)) for farm production equipment and the fuel use rate (in litres per one hundred kilometres (L/100 km), kilometres per litre (km/L) and miles per Imperial gallon (mpg)) for vehicles. The Farm Fuel Log Detail Report is intended mainly for use by the project team and the farmer-cooperator. It is particularly useful in spotting problems with the record keeping, such as lapses in recording fuellings, off-farm fuellings, inconsistent recording of use meter readings, etc.

The average fuel use rate (in L/h or km/L) computed for farm production equipment and vehicles, respectively, by operation, and for all operations combined, should be looked at critically in each case. Although records for which the use meter readings are zero were eliminated in calculating these averages, they can still be heavily influenced by one or more obviously erroneous records and should be adjusted for such. The problem varies greatly from farm to farm. It is hoped that having seen the results for 1982, all farmer-cooperators will see the benefit of keeping complete records for 1983.

To provide an overview of the results presented in the Farm Fuel Log Detail Report for each farm, they were summarized in the following computer-generated tables: Liquid Fuel Use and Fuel Use Rate* By Equipment, 1982 (Appendix B); Liquid Fuel Use By Operation, 1982 (Appendix C); Use of Diesel Fuel by 10-Day Period, 1982 (Appendix D); Use of Gasoline by 10-Day Period, 1982 (Appendix E); and Equipment Fuel Use by Month, 1982 (Appendix F). To reiterate, the results shown in these tables are preliminary and should not be used to draw conclusions.

FARM AREA AND PRODUCTION RECORDS

In order to calculate indices of fuel use per unit area, cropped and cultivated, and per unit of production, the necessary data were collected for each farm for 1981 and 1982. The results are summarized in Appendix G. Work on computing these indices is awaiting completion of the fuel-use analysis.

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*see previous paragraph regarding reliability of fuel use rate.

COST AND ENERGY CONTENT OF PURCHASED ENERGY FORMS

The data on quantities and dollar costs of purchased energy forms (fuels, electricity and fertilizers)* was standardized and processed by computer. The results were plotted as shown in Appendix H, pp. H-1 to H-21.

The data were supplied by the farmer cooperators, from their records. The data were not always complete. Sometimes we received only the cost figures and had to derive quantities from estimated unit prices. In such cases the energy contents plotted are subject to error, as unit prices for energy forms vary substantially. In some cases, the plots raise questions about the accuracy of the data. Such questions will be discusses with the farmers and any resulting corrections will be incorporated in the plots for the 1980-1983 period in the final FEMP report.

WORK IN PROGRESS

An attempt is being made to reconcile diesel fuel and gasoline purchases in 1982 with the totals dispensed through the fuel meters, off-farm purchases, estimate uses in the January to April, 1982, period, and estimated inventories at the beginning and end of 1982. Depending on the degree of success of this effort, additional data may be added to the data from the fuel log sheets already stored in the Fuel Log file and a final analysis performed to arrive at a liquid fuel use profile for the whole of 1982. Either these revised results, or the results now available from the log sheets for the May to December, 1982, period will be analysed and plotted in a number of ways.

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*We have used the word "purchased" as opposed to "used"; purchased energy forms may not be used or used entirely in the year in which they were purchased. Wood, included here as a "purchased" energy form at zero cost, is harvested on the farms on which it is used at no out of pocket expense. The cost of harvesting it is absorbed in other operations.

TASKS FOR YEAR 3

The key questions to be answered in Year 3 of the FEMP and the ones that justify its existence are:

(1) How much could energy use per unit of production be reduced, if the most energy-efficient technologies and practices available today were implemented?

(2) At what prices for the various energy commodities is it economical to implement such measures?

(3) What incentives can government create to accelerate, if desired, the rate at which it becomes economical to implement energy-efficient technologies and practices?

(4) What improvements in farm net income would these improvements in energy use provide?

(5) After these improvements in energy efficiency of use are achieved, could alternative fuels start being introduced? Examples of such fuels might be propane, compressed natural gas, ethanol or methanol.

CHAPTER 3

FARM ENERGY MANAGEMENT CHECKLIST

N.E. Jensen, farmer interviews and results by M. Gimby and W. Gamble

As a start on the technology transfer proposed in Phase III, a simple energy audit form was developed and tested. Figure 3.1 shows the audit format and entries for a two-family grain farm near Swift Current.

One of the owners* was interviewed to get his opinion of the potential for energy conservation. Here are some of his comments:

1. Good opportunities for conservation exist in the farm transportation category, especially non-loaded travel.
2. Doubtful if it would pay to use diesel grain trucks for the small distances travelled.
3. Already does gear-up/throttle down (originally for reduced noise level).
4. Tune-ups done regularly on all engines.
5. Expects to continue the trend to less tillage and more "once-over" operations (air-seeders and discers are both efficient machines for multi-job applications).
6. Interested in eliminating fall tillage.
7. Development is needed of a reliable tractor efficiency monitor to show % slip and power output per litre of fuel. This would assist the operator adjust depth, speed, etc. for best performance.

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*Not one of the 21 farmers involved in the farm energy management program.

Energy Type	Amount (Purchased (1982)	Cost	Main Uses
Marked Gasoline	14,500 L. (1,390 GAL.)	$ 4,350.	2 half-ton trucks 3 grain trucks 1 swather 1 combine
Clear Gasoline	8,013 L. (1,763 GAL.)	2,964.	3 cars
Diesel Fuel	7,053 L. (1,552 GAL.)	2,116.	3 tractors
Oil & Grease	--	400.	Tractors and Vehicles
Heating Oil	9,851 L. (2,167 GAL.)	2,955.	2 homes
Electricity	15,680 kWh	627.	1 farmstead 2 homes 1 shop
		$13,412.	

Figure 3.1 Simple Energy Audit:

This is an energy audit for a 648 ha (1600 acre) grain farm near Swift Current, Saskatchewan. The audit shows that the main energy cost on this farm is for the gasoline used in cars and trucks. Diesel fuel use in tractors is quite modest due to the minimum tillage practiced in the region.

This example illustrates the importance of analyzing all energy costs whether incurred for farm or personal use. Potential savings in the farm home and transportation categories are often as great as in the production sector.

8. Dirty or rusted cultivator shovels increase draft by at least 25% for many hours before they scour clean.
9. A lot of fuel gets used for cleaning. A high pressure steam cleaner may save energy.
10. Agrees that most farmers could easily save 10%.

Development of an Energy Management Checklist

On the basis of such interviews with farmers, and the many reports and articles on the subject, it was decided to prepare an energy management checklist, emphasizing the many small or medium magnitude management changes. (Large changes in cropping practices were handled separately - see Chapter 4).

The most profitable areas of energy management on any farm are the free and low-cost conservation measures which can be easily adopted. Because these ideas have little glamour they are often ignored in favour of more exciting but unproven renewable technologies.

The simple conservation ideas shown in the accompaning checklist can save 10 to 30% of the energy cost on most farms. Their values applied to all Saskatchewan farms, even at a 10% reduction in energy use, would save about $40,000,000 per year.

The checklist was derived from a larger study and manual being prepared (by N.E. Jensen) for Agriculture Canada as an energy management guide for farms across Canada. The farm energy management program offered an opportunity to test the energy management ideas suggested in the guide.

A simplified checklist was prepared, derived from the larger more complex manual. This simple checklist was tested with most of the farmers involved with our study. We were interested in answers to the following questions:

1. What changes have already been made?
2. What energy management techniques are (a) most popular, (b) least popular?
3. What are the reasons some techniques have been rejected?
4. What actions might be taken in the future?

We believed the results obtained with these farms (probably more energy conscious than the average) would be useful in extension activities to other farms.

The following two pages give the checklist which was tested with the farmers on the program:

ENERGY MANAGEMENT CHECKLIST

ACTION	COST	SAVINGS/YR. (SAMPLE FARM)	APPLICATION ON YOUR FARM?
A. FARM HOME			
1. Lower the furnace thermostat by 1°C (2°F)	NIL	$90.00	
2. Lower the hot water thermostat to 50°C (122°F)	NIL	$60.00	
3. Use less hot water	NIL	$58.00	
4. Turn off lights when not needed	NIL	$40.00	
5. Use smaller wattage light bulbs where adequate	NIL	$35.00	
6. Shop for energy-efficiency when replacing appliances	NIL	$50.00	
7. Weatherstrip and seal cracks	$200.00	$200.00	
8. Insulate basement	$500.00	$100.00	
•			
•			
•			
•			
B. FARMSTEAD			
1. Reduce unnecessary lighting	NIL	$50.00	
2. Plug in block heaters for only (2-3) hours	NIL	$30.00	
3. Shade fuel tanks to reduce evaporation	NIL	$80.00	
4. Paint fuel tanks a light color	?	$25.00	
5. Install pressure relief valves	?	$30.00	
•			
•			
•			
•			
C. CARS AND TRUCKS			
1. Reduce unnecessary travel (1 less trip to town per week)	NIL	$200.00	
2. Reduce idling	NIL	$100.00	
3. Drive 8 km./hr. slower	NIL	$100.00	
4. Keep tires at maximum recommended pressures	NIL	$50.00	
5. Operate engines at maximum recommended temperatures	NIL	$200.00	
6. Do more frequent tune-ups	$25.00 ?	$200.00	
7. Shop for energy-efficiency when replacing vehicles	NIL	$500.00	
•			
•			
•			
•			

ACTION	COST	SAVINGS/YR. (SAMPLE FARM)	APPLICATION ON YOUR FARM?
D. TRACTORS			
1. Reduce idling	NIL	$100.00	
2. Ballast for correct slippage	?	$200.00	
3. Match equipment for efficient operation	NIL	$150.00	
4. Gear up/throttle down for light loads	NIL	$200.00	
5. Shop for fuel efficiency when replacing tractor	NIL	$500.00	
•			
•			
•			
•			
E. CROP PRODUCTION			
1. Eliminate fall tillage	NIL	$500.00 ?	
2. Reduce depth of tillage	NIL	$500.00 ?	
3. Reduce field operations	VARIES		
4. Improve field patterns	NIL		
5. Soil test for fertilizer applications			
6. Use legumes as nitrogen source			
•			
•			
•			
•			
F. LIVESTOCK PRODUCTION			
1. Reduce lighting	NIL		
2. Check thermostats	NIL		
3. Select efficient equipment	VARIES		
•			
•			
•			
•			
G. GENERAL			
1. Apply for rebate on gasoline excise tax	NIL	$277.00	
2. Use 50% tax writeoff for heat recovery equipment	NIL		
3. Use 50% tax writeoff for manure storages and equipment	NIL		
4. Use 100% tax writeoff for land drainage improvements	NIL		
•			
•			
•			

Testing the Checklist

Eighteen of the cooperating farmers were interviewed to evaluate the checklist. It was found that these farmers have taken advantage of the majority of the low cost or no cost conservation techniques suggested in the checklist. As a rule, practices that increase energy efficiency tend to be readily accepted as long as they are consistent with the overall efficiency of the farm. It is important to note that energy conservation was not always the overiding motive for making these changes; i.e., a new vehicle was often bought without energy efficiency in mind, but better fuel efficiency was achieved because of changing manufacturing standards.

The following general comments refer to the categories listed in the checklist.

A. - Four farmers mentioned that when they reduced water temperature the dishwasher would not work properly.

- Two farmers mentioned that it was difficult to reduce lighting because small children would forget to turn the lights out.
- Several farmers mentioned installing fluorescent lights to reduce cost. There is a great deal of interest in the new fluorescent bulbs which screw into incandescent sockets.
- There are six houses on the project farms which have been built within the last three years. Energy conservation has been a major consideration in the design. Several energy efficient partial retrofits have been done on houses of farmers in the project.

B. - Two farmers mentioned that they would not reduce block heater plug-in time because they wanted to have the vehicle ready to go at all times (calving, in the middle of the night, etc.).

- Many farmers wanted information about timers for block heaters.

C. - Farmers with children mentioned that it was difficult to reduce miles travelled.

- In many cases farmers said that they would not drive slower (time is money) but would instead opt for more fuel efficient vehicles.

D. - Many farmers questioned the idea of reducing idling of their tractors because of fears of engine damage.

- Most farmers said that fuel efficiency was not the major factor when buying a new tractor. The deal that could be made and dealership reliability are of much greater concern than energy conservation. Tax considerations are also important for some farmers when buying new equipment.

E. - Many of the farmers in the program have moved to more continuous cropping rotations which reduces energy requirements for summer fallow but increase energy requirements for fertilizer.

- A few farmers mentioned they are unable to eliminate fall tillage because they are unable to get on the land in the spring if they do not.

- Avedex application and working in manure requires that the land be worked in the fall.

- Many farmers mentioned that they are reducing the number of summer fallow operations from the number of operations done a few years ago when fuel was cheap.
- Many farmers have buried rock piles and torn out fence lines etc., to make way for bigger equipment which has resulted in better field efficiency.
- Not many farmers do field tests on every field on an annual basis because they find recommendations are about the same from year to year.

F. - Some farmers are buying more energy efficient equipment and many are taking a long look at the entire feed system (a couple of farmers commented that silage is a big energy user).

G. - No comments.

The summary of the results of farmer interviews is given in Table 3.1. By comparison with the checklist, the reader can obtain an idea which conservation actions have already been taken, which ones are not popular and why, and which activities are likely to be tried in the future.

A high percentage of the farmers are already doing many of these energy conservation activities. Interesting question arise from the results of these interviews:

- How typical of all Saskatchewan farmers are the farmers on the study?
- Since our farmers are likely more energy conscious than average (they were chosen on the basis of their interest in farm energy management), is it likely that many of the actions already taken

Table 3.1 Summary of Interviews with 18 Farmers of the Energy Management Checklist

CHECKLIST CATEGORY #	TRIED AND REJECTED	ARE DOING	NOT TRIED AND WON'T	MIGHT	WILL TRY
A. 1	-	16	2	-	-
2	4	5	3	3	3
3	-	18	-	-	1
4	4	17	-	-	-
5	-	14	2	1	1
6	-	12	1	-	-
7	-	17	-	-	1
8	-	13	-	2	3
E=141	6/4%	112/79%	8/6%	6/4%	9/6%
B. 1	-	8	3	7	-
2	2	11	-	2	3
3	-	3	-	11	4
4	-	9	-	-	-
5	-	12	1	4	1
E=81	2/3%	43/54%	4/5%	24/30%	8/10%
C. 1	3	6	4	-	5
2	-	-	-	-	-
3	-	11	1	2	4
4	2	6	5	-	5
5	-	12	-	2	4
6	-	9	-	6	3
7	-	18	-	-	-
E=105	5/5%	62/59%	10/10%	10/10%	21/20%
D. 1	-	14	2	1	1
2	-	7	1	2	8
3	-	17	1	-	-
4	-	14	2	-	2
5	-	3	15	-	-
E=90	-	55/61%	21/23%	3/3%	11/12%
E. 1	-	11	4	-	-
2	-	18	-	-	-
3	-	14	1	3	-
4	-	9	-	9	-
5	-	13	4	1	-
6	-	6	10	2	-
E=105	-	71/68%	19/18%	15/14%	
F. 1	-	4	2	-	2
2	-	6	3	-	1
3	-	2	-	6	-
4	-	-	-	-	-
5	-	-	-	-	-
E=105	-	71/68%	19/18%	15/14%	
G. 1	-	16	2	-	-
2	-	1	17	-	-
3	-	-	-	-	-
4	-	-	-	-	-

by these 18 farmers remain to be adopted by many other farmers? If so, there is considerable opportunity to save other farmers money (and energy) in the future. In year III we will attempt to suggest a strategy for extension use of the audit forms.

Designing the Farm Energy Management Guide from Which the Checklist Was Derived

The plan was to give the farmer enough information to enable him or her to make a decision about a particular energy conservation subject without overwhelming the individual with too much data.

The manual was divided into the following categories:

Farm Energy Management
Farm Home
Farmstead
Transportation
Tractors
Crop Production
Livestock Production
Renewable Energy

Within a category a further subdivision was made:

e.g. Farm Home:

Construction
Retrofitting
Space Heating
Water Heating
Lighting
Appliances
Habits

Each subdivision would have one to several examples of particular energy conservation or energy management actions could be considered.

The following two pages give an example (farm fuel storage) of the format used. They give the basic information to make a decision, where to get more information, and a bit of background on the particular subject.

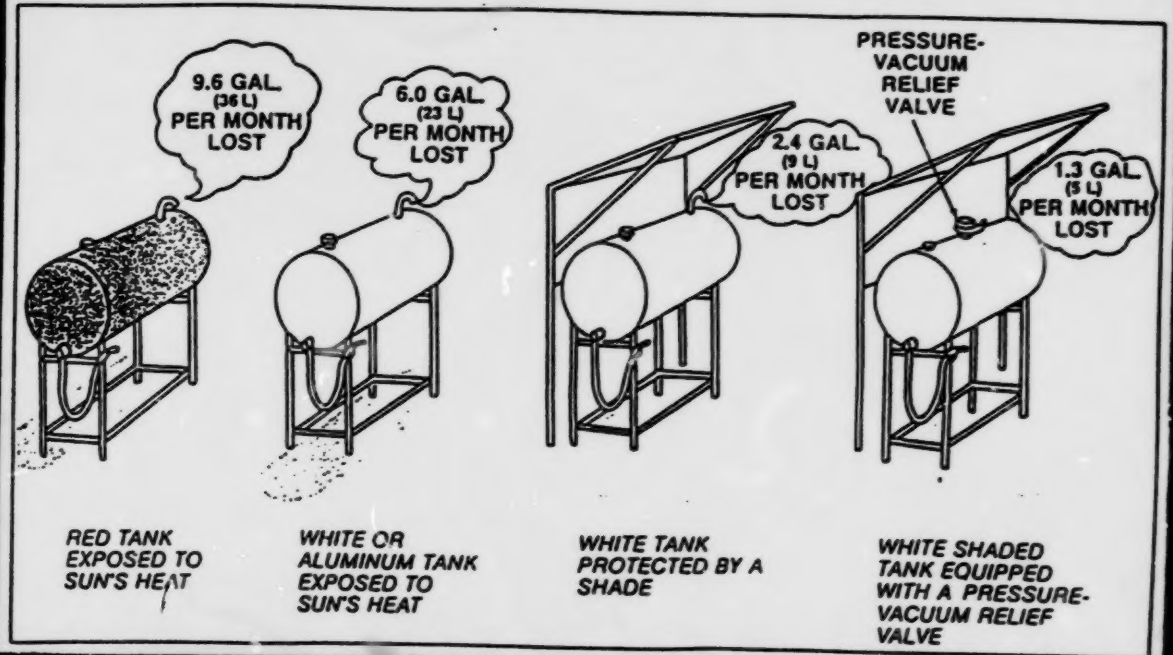
For a particular farmer, ag rep, farmstead engineer, or policy maker, the manual and the generalized sheet used with the farmers on the Farm Energy Management Program, could be used in several ways:

1. They can help identify actions which could save dollars and energy.
2. They could help make decisions about what to do first, and how to make a plan for future actions, as time and finances permit.
3. As more and more farmers used the forms, ag reps and engineers could get a good idea which conservation actions were popular, which needed technical improvement to make them more feasible, and which actions needed financial incentives to aid their more rapid introduction (if desired).
4. As we get an idea, from testing these manuals and and sheets with other farmers, which action are not adopted yet by the average farmer, but are likely to be over the next five years, policy makers can estimate the energy savings which are likely to be achievable. As part of the year 3 of the project we plan to estimate the

FARM ENERGY MANAGEMENT ANALYSIS

SUBJECT	FARM FUEL STORAGE
OBJECTIVE	To reduce fuel evaporation loss from an above-ground gasoline storage tank.
ACTION REQUIRED	(1) Paint tank white or silver. (2) Provide shade protection. (3) Install pressure relief valve.
COST	$100 (?)
EXPECTED SAVINGS	Measurements of summer evaporation from a 1135 L. tank showed that the above measures reduced losses from 36 L/month to 5L/month. Assuming average year-round savings of (20L/mo. x 12 mo.) = 240 L/year. Annual savings = 240 L x 30¢ = $72.00 Payback = 1.4 years.
OTHER THINGS TO CONSIDER	PRO Better fuel quality.
	CON
MORE INFORMATION	Fuel Storage - How To Avoid Problems And Save Money. Booklet available from Federated Co-operatives Limited, 401 - 22nd Street E., Saskatoon, Saskatchewan S7K 3M9.

Fig. 17—Summer Evaporation Losses From A 300-Gallon (1135 L) Gasoline Storage Tank


9.6 GAL. (36 L) PER MONTH LOST
6.0 GAL. (23 L) PER MONTH LOST
2.4 GAL. (9 L) PER MONTH LOST
PRESSURE-VACUUM RELIEF VALVE
1.3 GAL. (5 L) PER MONTH LOST
RED TANK EXPOSED TO SUN'S HEAT
WHITE OR ALUMINUM TANK EXPOSED TO SUN'S HEAT
WHITE TANK PROTECTED BY A SHADE
WHITE SHADED TANK EQUIPPED WITH A PRESSURE-VACUUM RELIEF VALVE

energy savings which could be achieved if farmers adopted these energy conservation measures. This should give an indication of the magnitude of the energy efficiency improvements achievable.

The complete farm energy management guide is being prepared on a separate contract by one of us (N.E.J.) to Agriculture Canada. It is anticipated that copies of the guide will likely be available before the end of Year III of this project.

CHAPTER 4

EXEMPLARY FARM ENERGY AND VARIABLE COST ANALYSIS CONVENTIONAL TILLAGE AND CHEMICAL FALLOW SYSTEMS

A.A. Rutherford

INTRODUCTION

Traditionally, prairie agriculture has employed various forms of tillage in cereal grain cropping patterns, particularly short term 2 or 3 year rotations. Over the years, new crop varieties, mechanization, successive adoption of herbicide weed control and increased use of commercial fertilizers have sustained or improved overall production. Throughout such improvements the extent of tillage has remained more or less unchanged.

Located for the most part under semi-arid climatic conditions, summerfallowing has been practiced for soil moisture conservation with additional benefits in essential nutrient regeneration and to some extent perennial weed control. Long experience has shown a lower risk in terms of crop yield and operating expenditures in short cropping rotations, thus tending to entrench the practice as a favored part of farm management. Even more favorable climatic areas during times of high grain inventories frequently revert to fallowing under economic stress periods. However for some years, soil specialists have expressed concerns over organic matter decline associated with natural fertility reduction and certain aspects of soil physical structure deterioration. Excessive tillage has been implicated, hence a dilemma for the more arid soil zones. Abatement suggestions advocate the substitution of herbicides for tillage with effective snow trapping in more continuous cropping systems. More than a decade of alternative investigations are now evolving some plausible options.

In part, the Farm Energy Management Program objectives include net energy and related economic evaluations of long established and more recent proposed alternative farm practices. As indicated modern farming is increasingly dependent on direct and indirect forms of energy with escalating costs, therefore considerations cover a range of specific and general cropping techniques. Analyses are based on data derived from this current program or drawn from reports of agricultural organizations. The underlying concept is to identify practices that have mutual soil conservation, energy and economic merit. Commonly agricultural reporting emphasizes crop yield performance on assumptions of more or less uniform production input cost. Noteably newer proposals exhibit variable departures. On going efforts herein are directed toward a broader prospective, intended as an aid in technology transfer to the farm level. It should be recognized from the above viewpoint that maximum production does not necessarily coincide with optimum net energy and income returns. However in practical terms, farm scale operations inevitably require some compromises.

The presentation to follow illustrates work in progress. It is an initial phase comparison of conventional tillage to chemical summerfallow in trials underway on FEMP Farm 9, located in the Dark Brown Soils of west-central Saskatchewan. Data has been kindly provided by Dr. K. Foster, Crop Development Centre, University of Saskatchewan.

MATERIALS AND METHOD

Experimental Data

Briefly, the continuing field-scale 2 year rotation conventional tillage and chem-fallow treatment comparison is a four replication split-plot experimental design to permit phosphate fertilizer (11-51-0) application with seeding at 0 and 33 kg/ha rates; superimposed is discer and no-till drill planting (67 kg/ha) to determine minimum tillage seeding implement effects. In addition to yield response data collection, plant growth characteristics and weed species populations are being monitored.

Due to land area limitations, fallow treatments and spring wheat cropping occurs in alternate years, to date 1981 and 1982 respectively. Correspondingly the analysis covers this two year period. As such the results are somewhat subject to individual year climatic conditions as compared to long time averages.

Analytical Procedure

The analytical approach adopted is in the format of a partial budget excluding labor and fixed overheads in land, buildings and machinery inventory inputs. Also omitted are miscellaneous costs of seed, crop insurances and marketing delivery. Considered in parallel are energy consumption (direct and indirect) and expenditures for fertilizer, herbicides and field operations (e.g. fuel, oil and machine maintenance repairs). It is believed to be in line with producer thinking when considering nominal alterations in cropping practices (i.e. no major shift in capital inventories). Hence the analyses presents the net cash return at the farm gate rather than an overall net income assessment.

Pricing represents general 1982 conditions for input commodity purchases. In so far as field operations are difficult to accurately determine, types of operations have been priced according to averages derived from the "Saskatchewan Agriculture Custom and Rental Rates 1982" schedule omitting labor depreciation and margins. While not specific to the study, they may be regarded as reasonably representative for a range of equipment size as to cost per hectare. Detailed computations are appended. Grain revenue likewise has been modified as an average of grades #1 and #2 to compensate for years when wet harvest weather may lower quality. An assigned value of $186.00 per tonne has been used projecting similar returns for 1982-83 as for 1981-82 wheat deliveries (i.e. elevator price plus final CWB final payment). Any overall price reduction will correspondingly lower net cash returns given.

Results and Discussion

General yield response to fertilizer and seeding method in the summerfallow treatment comparison are given in Table 4.1.

Table 4.1 The Effect of 1981 Summerfallow Practices on 1982 Wheat Yield, Phosphate Fertilizer and Seeding Implement Comparisons (Kg/ha).

Fallow Practice	Conventional Tillage		Chemical Tillage	
Fertilizer (Kg/ha)	0	33	0	33
Implement				
Discer	2388	3206	2843	3573
No-till Drill	2274	3041	2532	3643
Means	2331	3124	2688	3608
	2727		3148	

Readily apparent is a dominant phosphate fertilizer effect: irrespective of seeding method, yield advantages of 793 and 920 Kg/ha for conventional and chem-fallow treatments respectively (i.e. 11.8 and 13.7 bu/acre).

Noteably in all treatments chem-fallow out performs conventional tillage, averaging some 421 kg/ha better (6.3 bu/acre). Except for a marginal yield increase (70 kg/ha, ≈ 1 bu/acre) for the high fertilizer rate on chem-fallow, discer seeding gave more positive effects than the no-till drill. Hence the preliminary results suggest only limited advantage in seeding equipment change in adopting the apparent higher yielding chem-fallow system.

Table 2 presents in detail the net energy and cash return for individual treatments. For the less familiar energy budgets, standard energy values in gigajoules per kilogram or litre (GJ = 10^9 joules, ≈ 10^6 BTU) have been used for output and input products as outlined in previous publications "Boerma H., Gimby M., and Coxworth E., 1980. A Study of the Energy Consumption of Different Agronomic Practices in Saskatchewan Year III, Saskatchewan Research Council Technical Report No. 103". In effect the analyses estimates the metabolisable energy content of the wheat produced over and above equivalent energy inputs (e.g. fuel, fertilizer, herbicides). Net values reflect both differences in yield and type of input variations. The results indicate little overall difference in energy inputs on the basis of identical treatment: Conventional tillage's high field fuel consumption (≈ 20 ℓ/ha diesel) is more or less offset by equivalent indirect energy of herbicides for chem-fallow.* Essentially individual treatment differences are largely attributable to yield response. Chem-fallow out ranks conventional summarfallow practice under comparable fertilizer applications.

Other studies by Lindwall (quoted in Boerma, Gimby and Coxworth, 1980) gave lower energy costs for herbicides so that a chem-fallow system gave about 1/2 the energy inputs of conventional fallow.

Table 4.2 Two Year (Fallow-wheat) Rotation Comparison of Conventional Tillage and Chemical Fallow Systems; Phosphate Fertilizer and Seeding Implement Effects (U of S Plot Trials, west-central Dark Brown Soils).

Data Years	1981-82															
Output/Input Comparison	Energy GJ/ha								Return/Variable Cost $/ha							
Fallow Practice	Conventional				Chem-Fallow				Conventional				Chem-Fallow			
Phosphate Fertilizer (Kg/ha)	0		33		0		33		0		33		0		33	
Seeding Implement	Discer	No-till	Discer	No-till	Discer	No-till	Discer	No-till	Discer	No-till	Discer	No-till	Discer	No-till	Discer	No-till
1. Gross Return Output																
Yield Kg/ha	2388	2274	3206	3041	2843	2532	3576	3643	2388	2274	3206	3041	2843	2532	3576	3643
(bu/acre)	(35.5)	(33.8)	(47.7)	(45.2)	(42.3)	(37.7)	(53.2)	(54.2)	(35.5)	(33.8)	(47.7)	(45.2)	(42.3)	(37.7)	(53.2)	(54.2)
Value (yield less seed)	31.56	30.02	42.69	40.45	37.75	33.52	47.72	48.63	431.71	410.50	583.85	553.16	516.34	458.49	652.67	665.14
2. Variable Input																
Fallow Year (1981)																
Tillage	1.03								13.58							
Spray	0.09*				1.06				14.00*				108.01			
Crop Year (1982)																
Fertilizer, 60 Kg/ha (11-55-0)	--		1.44		--		1.44		--		18.53		--		18.53	
Seeding	0.29	0.34	0.29	0.34	0.29	0.34	0.29	0.34	4.37	6.12	4.37	6.12	4.37	6.12	4.37	6.12
Herbicides (Hoegrass-Torch)	0.39				0.39				41.38				41.38			
Harvest operations (Swath, combine, Grain Handling)	0.77				0.77				17.16				17.16			
Total	2.57	2.62	4.01	4.06	2.51	2.56	3.95	4.00	90.49	92.24	109.02	110.77	170.92	172.67	189.45	191.20
3. Net Return																
(Excl. labor and Fixed overheads)	28.99	27.40	38.68	36.39	35.24	30.96	43.77	44.63	341.22	318.26	474.83	442.39	345.42	285.82	463.22	473.94
Adj Net Return/ha/a	14.50	13.70	19.34	18.20	17.62	15.48	21.89	22.32	170.61	159.13	237.42	221.20	172.71	142.91	231.61	236.97
(1 acre/a)	(5.87)	(5.54)	(7.83)	(7.36)	(7.13)	(6.26)	(8.86)	(9.03)	(69.04)	(64.40)	(96.08)	(89.52)	(69.89)	(57.83)	(93.73)	(95.90)
Ranking	7	8	3	4	5	6	2	1	6	7	1	4	5	8	3	2

* Spot spray with Roundup @ 2.25 l/ha approximately 1/4 area for Canada Thistle Control, also included in Chem-fallow spray value.

In economic terms, phosphate fertilizer treatments show distinct net cash return benefits, on average $70.46/ha per year for the $18.53 investment. On specific treatment comparison, chem-fallow yield advantages tend to diminish because of the large fallow year herbicide expenditure. As shown, probable rational options (e.g. conventional fallow-discer seeding; chemical fallow-discer or no-till drill seeding) produce more or less identical income estimates. Elimination of the spot herbicide application on the conventional fallow (i.e. Canada Thistle control by tillage) would place the chem-fallow practice in a secondary economic position. Hence there is an obvious need to explore ways to reduce herbicide cost.*

CONCLUSIONS

As an initial phase analysis, it is premature to draw any firm conclusions. The experimental program as conducted indicates chem-fallow to have net energy merit although overall energy input to the two systems are quite similar (i.e. little energy conservation). Economically, chem-fallow appears only tentatively comparable to conventional tillage fallow due to chemical expense. It has characteristically a higher cash flow requirement which under grain marketing restrictions would have some adverse consequences.

A more extensive review is in progress on data furnished by Agriculture Canada, Melfort Research Station. It relates to long term work (1968-82) on tillage, various herbicides, and combinations thereof for summerfallowing in a similar fallow-wheat cropping plan. On completion a more conclusive assessment can be given.

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* Information from K. Foster indicates lower cost (in dollar and energy inputs) herbicides will be available this year (1983).

APPENDIX

Detailed Farm Energy and Variable Cost Analysis

1. Pricing Schedule (1982)

Fuel- Diesel - \$1.37/gallon (30.4¢/ℓ)

Purple Gas - \$1.46/gallon (32.4¢/ℓ)

Oil and Grease maintenance 35¢/100 HP

Fertilizer - (11-55-0) - \$308.00/tonne

Herbicides - Roundup - \$245.00/10 ℓ

Torch - \$168.00/20 ℓ

Sweep - \$177.00/22 ℓ

Hoegrass- \$160.00/20 ℓ

2,4-D Amine- \$64.50/20 ℓ

Field Operations - Fuel consumption and variable maintenance cost per hectare (Saskatchewan Agriculture Farm Machinery Custom and Rental Rates, 1982) Labor, Fixed Costs and Margins excluded.

Grain - Wheat average grades 1 and 2 - \$186.00/tonne

(Elevator price at delivery point plus estimated final payment at \$26.71/tonne).

2. 1981 Summerfallow Year

A)

Conventional Tillage System	ℓ/ha	Energy GJ/ha	Variable Cost $/ha
2 x H.D. Cultivator	(2 x 4.55) 9.10 (D)		(2 x 2.57) 5.14
1 x Rodweeder	(1 x 2.26) 2.26 (D)		(1 x 1.52) 1.52
2 x F. Cultivator and Rodweeder	(2 x 5.75)11.64 (D)		(2 x 3.46) 6.92
	0.0452 GJ/ℓ x 22.80 (D) =	1.0306 GJ	$13.58

Add-on spot spray with Roundup for Canada Thistle Control = 1/4 area.

1/4 Sprayer (1/4 x 1.03)	0.26 (D)		(1/4 x 0.88) 0.22
0.0452 GJ/ℓ x 0.26 (D) =		0.0118	
Roundup 1/4 x 2.25 ℓ/ha x 0.1378 GJ/ℓ =		0.0775	13.78
		0.0893	$14.00
		1.1199 GJ	$27.58

B. Chemical Fallow System	ℓ/ha	Energy GJ/ha	Variable Cost $/ha
3 x Sprayer (3 x 1.03)	3.09 (D)		(3 x 0.88) 2.64
0.0452 GJ/ℓ x 3.09 (D)		= 0.1397	
#1 Roundup @ 1.2 ℓ/ha x 0.1378 GJ/ℓ		0.1654	29.40
and Torch @ 1.3 ℓ/ha x 0.0897 GJ/ℓ		0.1166	10.92
#2 Sweep @ 2.25 ℓ/ha x 0.1038 GJ/ℓ		0.2336	18.10
and 2,4-D Amine @ 1.1 ℓ/ha x 0.0410 GJ/ℓ		0.0451	3.55
#3 Roundup @ 1.2 ℓ/ha x 0.1378 GH/ℓ		0.1397	29.40
		0.8401 GJ	$94.01
Add-on spot spray with Roundup for Canada Thistle Control = 1/4 area as for conventional fallow		0.0893 GJ	$14.00
		0.9294 GJ	$108.01

3. 1982 Crop Year (Wheat)	ℓ/ha	Energy GJ/ha	Variable Cost $/ha
Fertilizer (11-55-0) 60 Kg/ha			
33 Kg/ha P_2O_5 x 0.0203 GJ/Kg =		0.6699	18.53
6.6 Kg/ha N x 0.1166 GJ/Kg =		0.7696	
		1.4395 GJ	$18.53

	ℓ/ha	Energy GJ/ha	Variable Cost $/ha
Herbicides (all treatments)			
1 x Sprayer (1 x 1.03)	1.03 (D)		(1 x 0.88) 0.88
0.0452 x GJ/ℓ x 1.03 (D)		= 0.0466	
Hoegrass @ 3.75 ℓ/ha x 0.0623 GJ/ℓ		= 0.2336	30.00
Torch @ 1.25 ℓ/ha x 0.0897 GJ/ℓ		= 0.1121	10.50
		0.3923 GJ	$41.38
Seeding Implement			
1 x Discer (1 x 6.42)	6.42 (D)		(1 x 4.37) 4.37
0.0452 GJ/ℓ x 6.42 (D)		= 0.2902	
		0.2902 GJ	$4.37
OR			
1 x No-till Drill (1 x 7.53)	7.53 (D)		(1 x 6.12) 6.12
0.0452 GJ/ℓx 7.53 (D)		= 0.3404	
		0.3404 GJ	$6.12
Harvest			
1 x Swather (pull type) (1 x 2.36)	2.36 (D)		(1 x 1.61) 1.61
1 x Combine (SP) (1 x 9.11)	9.11 (D)		(1 x11.27) 11.27
0.0452 GJ/ℓx 11.47 (D)		= 0.5184	
Grain handling to bin (0.385 hr combining/ha)			
Auger 10% time			
(0.10 x 0.385 x 1.14 ℓ/hr)	0.04 (G)		0.05
Truck 70% time			
(0.70 x 0.385 x 22.27 ℓ/hr)	14.83		4.23
0.0412 GJ/ℓ x 14.87 (G)		= 0.6126	
		1.1310 GJ	$17.16

New cropping practises: what are young farmers planning to do?

In March, 1983, M. Gimby of the FEMP research team was asked by Professor Stan Rowe of the Plant Ecology Department, to present a series of lectures to a class of Vocational Agriculture students at the U. of S. The theme of the lecture series was an integrated approach to new energy conserving cropping systems. A questionnaire was presented to the class asking the students to comment on any new cropping techniques being adopted on their own farms. There were 12 students out of 22 who answered the questionnaire.

An example of the questionnaire is presented below.

Name: ______________________________

Address: ______________________________

Farm Size: ______________________________

Cropping Rotation: ______________________________

Soil Zone: ______________________________

Indicate whether the following alternative cropping practices apply to your farm:

	NO	YES	ACRES AFFECTED	YEAR PRACTICE BEGUN
Reduced tillage				
Continuous cropping				
Legumes in rotation				
Winter wheat				
Chemical fallow				
Snow management				
Organic farming				

If you have not begun implementing one of the above practices, but have plans to do so in the near future, please indicate:

The results of the questionnaire are as follows:

REDUCED TILLAGE - Seven answered 'yes' and one indicated that this practice would be seriously considered in future. All but one indicated that reduced tillage had begun within the past four years.

CONTINUOUS CROPPING - Four indicated that they had begun experimenting with a continuous cropping system during the past few years. Two said that this practice was being given serious future consideration.

LEGUMES IN ROTATION - Two said they are using sweet clover as a green manure crop. One has begun growing lentils. Two indicated that legumes in rotation as a plough-down crop was being given serious future consideration.

WINTER WHEAT - Two have begun producing winter wheat on small acreages during the past three years. Three indicated that they are giving winter wheat production serious consideration.

CHEMICAL FALLOW - One student indicated that he had started using chemical fallow last year and one indicated that he was going to start using this practice in 1983.

SNOW MANAGEMENT - Seven students indicated that snow management was being practiced on their farm. They have all begun this practice within the past four years. Three indicated that they were soon going to begin trapping snow.

ORGANIC FARMING - One student said that he was producing organic grain for specialty food chains.

CHAPTER 5

USES OF AERIAL PHOTOGRAPHS IN FARM ENERGY ANALYSIS

N.E. Jensen

Two types of aerial photos were obtained for each project farm:

1) Black and white township photomaps available for all of Saskatchewan from the Department of Tourism and Renewable Resources. These maps have been produced from aerial photographs taken in 1979.
2) Infrared color photographs were supplied under contract by Prairie Agri-Photo Ltd. These photos were taken in mid-summer of the study year (1982).

Energy Analyses

Potential energy management uses for aerial photos include:

1) Evaluation of field configurations for efficient equipment operation.
2) Evaluation of the relative efficiency of various field working patterns.
3) Determination of the losses in field efficiency due to obstructions, such as sloughs, rock piles, trees, power poles, oil and gas wellsites, etc.
4) Identification of fertilizer and herbicide misses and overlaps.
5) Testing of variable fertilizer application rates.

Photo Evaluation

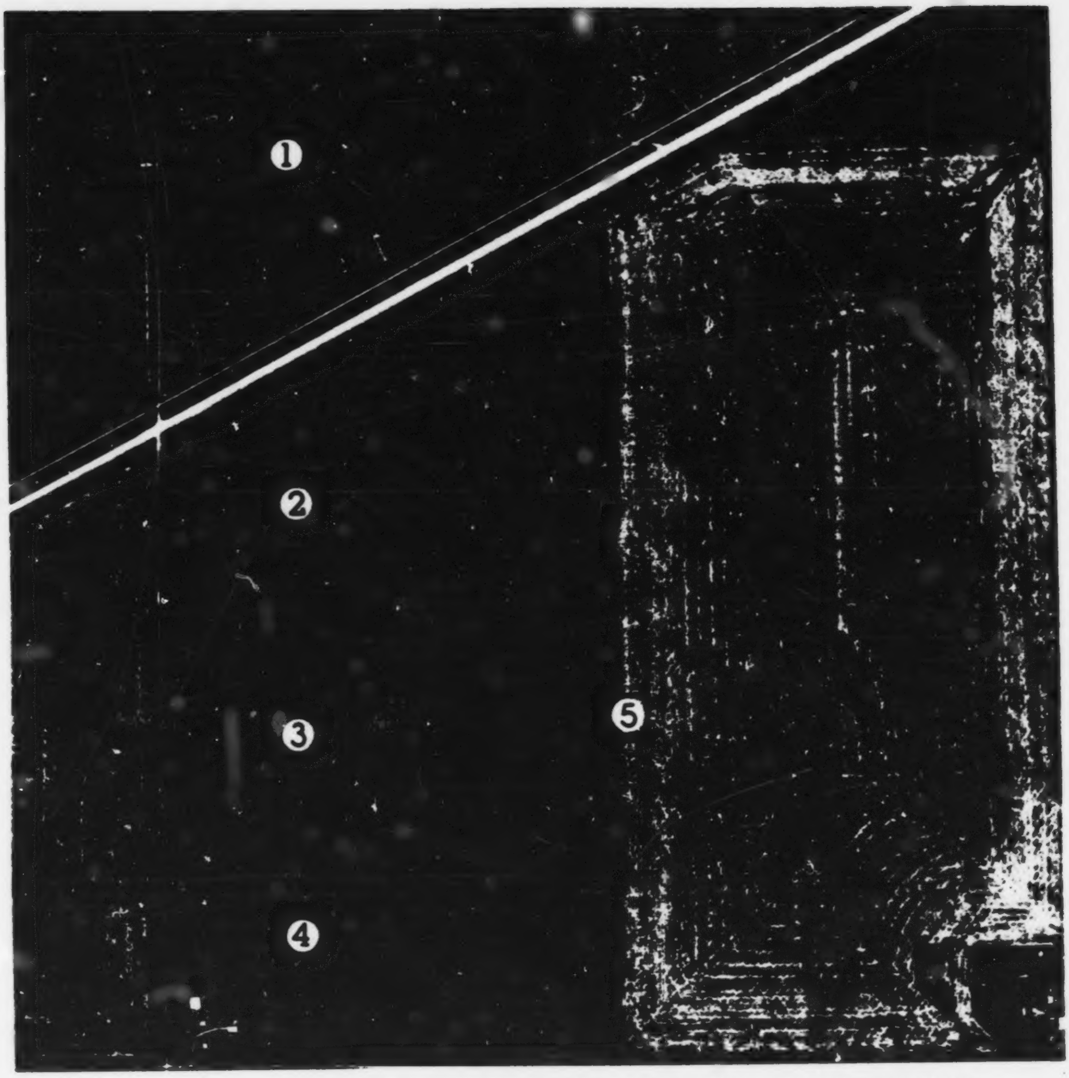
While the township photomaps were useful for assessing general features on a farm, they did not provide the scale or clarity needed for analysis of specific fields. The infrared photos were much more useful because they provide a larger scale, gave color differences in crops, and showed a current image of the farm. Figure 5.1 illustrates some of the features which can be detected by aerial infrared photography. It is apparent that with some interpretation assistance, farmers could use these photos to improve their fertilizer management.

Computer Analysis of Photos

Jensen Engineering Ltd. has developed a micro-computer digitizing system to enlarge and plot features from an aerial photo. This equipment, although developed for another client, was demonstrated at the Farm Energy Management Seminar (November, 1982). The farm participants were particularly interested in the rapid calculation of slough areas. Many of the project farms are severely affected by sloughs and small potholes which prevent efficient equipment operation.

Potential for Computer Analysis of Field Efficiency

The Physics Division of SRC was subcontracted to examine the possible use of aerial photos for a computer simulation of field operations. Budget constraints permitted only a first step in this analysis. As shown in Figure 5.2, a computer program was developed to plot scaled plans of each farm from the photos.



The deeper red color indicates healthy plant growth. A pinkish color indicates stressed plants.
The greenish tint represents soil showing through a seedling crop or sparse plant growth.

Granular fertilizer spreading problem ①
Liquid fertilizer misses ②
Nitrogen ran out in a wheat field ③
Drainage problem in a flax field ④
Phosphate ran out in a barley field ⑤

Figure 5.1 Uses of infrared photography for crop evaluation.

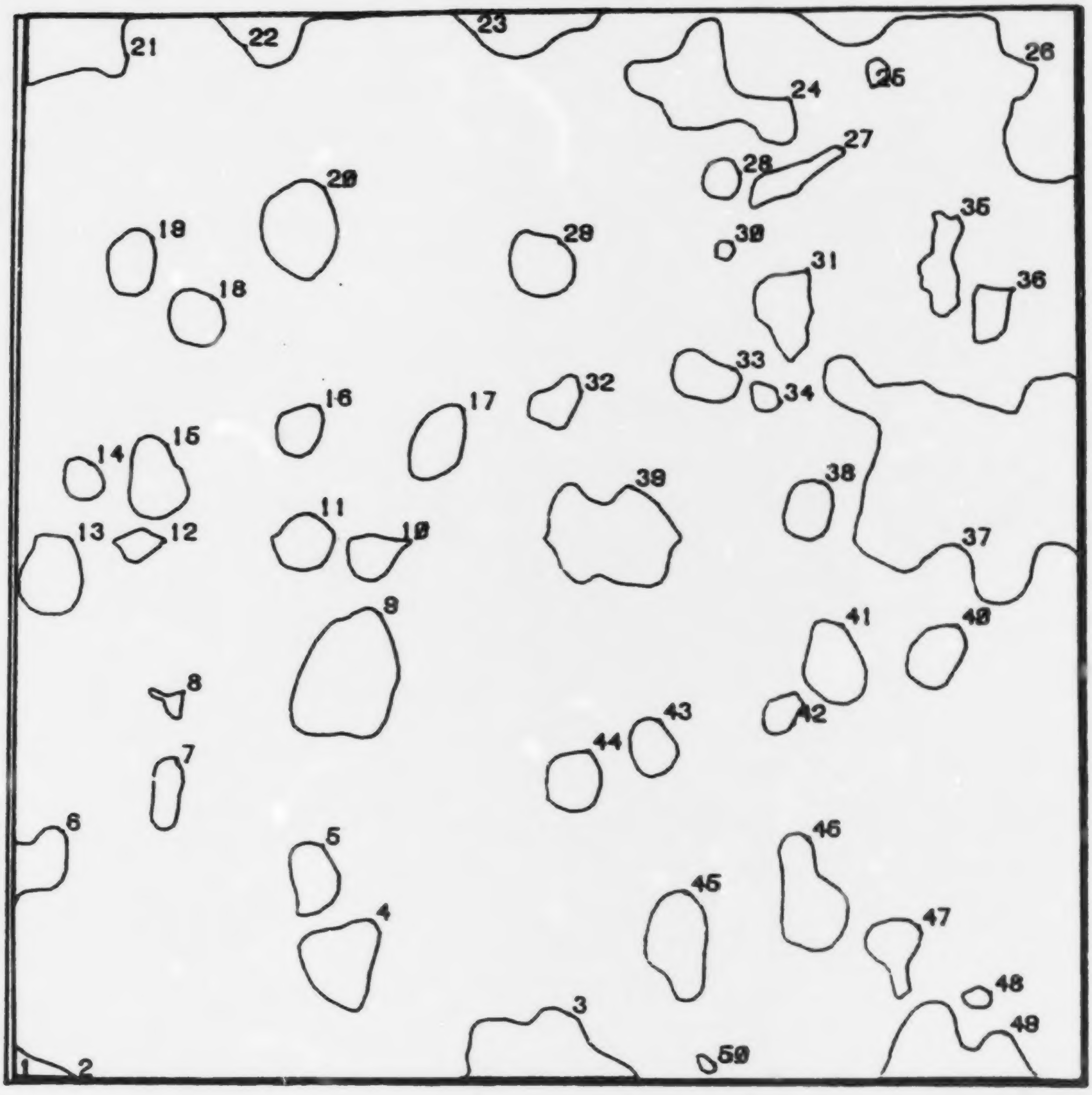


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Figure 5.2 Computer plot of Section derived from infrared aerial photography.

This example shows a severe problem with sloughs on a section of land near Weyburn. The analysis (Table 5.1) indicates that the total area of sloughs is 113.4 acres. The loss in field efficiency is very serious due to the many obstructions. Farmers suggest that the wasted fuel, fertilizer and herbicide due to overlapping may be as high as 25% on many fields.

Subsurface drainage pipe can be used to consolidate these sloughs and improve the field efficiency. It is possible that the total field could be cropped with no increase in production costs (and a definite reduction in fuel requirements). To test this it would be useful to have a method for evaluating the effect of obstructions in a particular field. The next step to achieve that goal is to develop a criterion for evaluating the loss in field efficiency for a given configuration of obstructions. In 1983 the owners of this farm plan to attach a distance measuring device to their tractor to determine the total distance travelled in one tillage operation on the field. This will then be compared to the theoretical travel distance calculated for a similar size field with no obstructions.

It may eventually be possible to use an interactive graphic system to simulate equipment operation and estimate the wasted fuel and time for a given field.

Table 5.1. Computer calculations for areas of sloughs in Figure 5.2.

```
CLIENT:
MUNICIPAL LAND LOCATION:
AREA IDENTIFICATION:      J06

AREA #                    AREA (ACRES)     PERIMETER (FT)
------                    ------------     --------------

1                         627.3              20885
2                          -0.5                774
3                          -4.3               2145
4                          -2.8               1335
5                          -1.5                978
6                          -1.5               1138
7                          -1.0                871
8                          -0.3                537
9                          -5.7               1879
10                         -1.1                869
11                         -1.4                907
12                         -0.6                629
13                         -2.2               1142
14                         -0.7                640
15                         -2.0               1116
16                         -1.0                776
17                         -1.7               1032
18                         -1.4                885
19                         -1.4                912
20                         -3.2               1352
21                         -3.3               1692
22                         -1.9               1906
23                         -2.5               1735
24                         -5.2               2452
25                         -0.3                397
26                         -8.3               4731
27                         -1.1               1183
28                         -0.6                604
29                         -1.9               1036
30                         -0.1                297
31                         -2.0               1226
32                         -1.0                814
33                         -1.4                930
34                         -0.4                462
35                         -1.6               1299
36                         -1.0                830
37                        -21.6               4971
38                         -1.3                863
39                         -5.5               2009
40                         -1.5                948
41                         -2.1               1135
42                         -0.6                632
43                         -1.1                813
44                         -1.5                921
45                         -2.8               1367
46                         -3.0               1514
47                         -1.4               1075
48                         -0.2                388
49                         -3.8               2078
50                         -0.1                278
------------------------------------------------------------

TOTAL OF '+' AREAS =    627.3 ACRES        20885 FEET
TOTAL OF '-' AREAS =    113.4 ACRES        60503 FEET

NET CULTIVATED AREA    =    513.9 ACRES
                            ===========
```

CHAPTER 6

POSSIBLE FARM PROJECTS FOR 1983

M. Gimby and W. Gamble

FARM #1

- Gear up - throttle down.
- Interested in developing a central heating system for the farmyard which can burn bales, garbage, used oil, etc. This system would be used to provide heat for two houses and a shop.

FARM #2

- Gear up - throttle down.
- Would like to test the on-board Halda fuel monitors.

FARM #3

- Wants assistance for further insulating the farm house.
- The Halda fuel monitor will be installed and tested on the White tractor.
- Using last years' infrared aerial photographs, fertilizer is going to be applied in large amounts to test plots in those areas that are seen to be badly eroded. The IR photos will be taken again this year to see if they can detect a growth response.

FARM #4

- Interested to know if aerial photos can help detect spots in the field (with extra moisture or nutrient) where extra fertilizer and seed would result in higher yields and profit. Intends to set up some plots that he would like photographed again this year.

FARM #5

. Use IR photos of Farm Lab (U of Sask.) experiments to detect growth patterns.

. Wants to prevent movement of truss rafters in his home because of uneven insulation in the roof.

FARM #6

. Gear up - throttle down.

. Wants information on wood stove installation.

. Wants to separately meter electrical use for the livestock operation and the grain drying operation.

. Wants information on the economics of different manure application techniques.

. Aerial IR photographs of the Farm Lab experiments.

. Interested in winter wheat production.

FARM #7

. Gear up - throttle down.

. A continuous cropping system is being attempted on 320 acres and can be compared to a two year system.

. Wants to separately meter electrical use for the hog operation.

. Wants information and assistance for wood stove installation.

FARM #8

. Testing Halda fuel meter on big truck.

- Changing from conventional seeding with press drills to the use of air seeders. Will monitor the changing energy requirements for the new system.

FARM #9

- Continuation and redesign of zero till experiments with the U of S.
- Wants information for partial housing retrofit.

FARM #10

- Would like to investigate the feasibility of passive solar heat system for the dairy barn.
- Wants to determine most efficient system for cooling the milk bulk tank.

FARM #11

- Gear up - throttle down.
- Would like to test the on-board Halda fuel monitors.
- Interested in testing winter wheat production using strips of flax for trapping snow on summerfallow.

FARM #12

FARM #13

- Will require information and assistance for expansion and retrofit of hog barn.

FARM #14

. Will participate in on-farm project to analyze changes in equipment operating techniques.

FARM #15

. The Halda fuel monitor will be installed and tested on the Versatile tractor.

. Are interested in fertilizer application technology and will participate in on-farm project.

FARM #16

. Will participate in on-farm project to test fertilizer efficiency project.

. Wants to participate in analysis of conversion to a conservation farming system.

FARM #17

. On-farm operating techniques.

FARM #18

. On-farm fertilizer efficiency project.

FARM #19

. Gear up - throttle down.

. Operating techniques.

FARM #20

. Participated in Gear up - throttle down.

. Replacing some vehicles, and will attempt to compare change in efficiency with last year.

FARM #21

. Wants to separately meter electrical use for the dairy barn.

. Needs assistance for making changes to energy efficient house design.

. Will be comparing the fuel requirements for working hilly land as compared to working level land.

. Would like to investigate the most efficient way for applying manure to cropland from dairy barns.

FARM #22 (New farm added late in year 2 of the project).

. Using a minimum till winter wheat cropping system. Will monitor the energy requirements for this system.

. An electrical split will be required to monitor electricity required for the airation drying system.

APPENDIX 1.

Summary of fuel use on all farms

Work in Progress

The following pages give examples of the data collected which are still being evaluated. These data need to be checked further (in progress) since in a number of cases there are discrepancies in fuel use as measured by the fuel meters, and as recorded or estimated from fuel purchase receipts. Once the data are corrected (we hope by early summer) they will be analysed in different methods; e.g.:

- fuel use by the time of the year
- fuel use per cultivated acre or hectare
- fuel use per unit of product (bushel or tonne of wheat, per calf sold, etc.).

Simulation runs could be carried out to estimate how much energy (liquid fuels) could be conserved on each farm, if currently available technology were used in each operation. For example, the age of all cars, small trucks and large trucks has been recorded. Given estimated ages of vehicles at which they would likely be replaced, and known improvements in fuel efficiency of new cars and trucks, the improved efficiency of liquid fuel use in transport could be calculated. Given no changes in driving distances, we could then calculate the reduction in transport liquid fuel use in (say) 1988.

These sorts of calculations are planned for year 3. A separate publication is contemplated dealing with liquid fuels use on farms, covering the subjects just mentioned. Part of the process of preparing this publication will be further discussions with the farmers to get their ideas and suggestions, and to plan possible liquid fuel conservation experiments (this will include the gear up-throttle down experiments with tractors taking place in Professor Zoerb's contract).

The report on liquid fuel use (to be published later in 1983) will include descriptions of the types of farms and farm operations. These have been described in the year I report.

The reader is reminded that the data reported herein are preliminary and subject to further revision as described earlier.

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Mon Mar 28 18:33:52 1983 — Farm No. 1 — Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Car, Oldsmobile, 1979	1535			10.3	9.7	27
Skidsteer loader, Case 1845	602	3.5	0.8			
Supplied to others	246					
Tractor, John Deere 4430, 1973	6486	13.4	2.9			
Tractor, John Deere 8440, 1980	11457	30.7	6.8			
Tractor, IHC 706, 1965	769	4.5	1.0			
Total	21095					
Gasoline						
Auger	5					
Car, Plymouth, 1976	1002			17.3	5.8	16
Garden tractor	87					
Pump	10					
Supplied to others	40					
Swather, IHC 230, 1975	1212					
Truck, 1/2 ton, Ford, 1976	1704			24.7	4.0	11
Truck, 3 ton, Ford, 1970	1009					
Truck, 3 ton, Ford, 1973	1830					
Total	6899					

```
               Liquid Fuel Use by Operation, 1982

  Mon Mar 28 19:20:43 1983            Farm No. 1                                  Page 1

  Operation                               Diesel Fuel              Gasoline      Total
                                         L          GJ           L        GJ        GJ

  Farmstead                                                     87         3         3
  Feed                                 837          32         310        11        43
  Harvest & hauling                   3883         150        3059       106       256
  Land improvement                      81           3                               3
  Livestock miscellaneous              143           6                               6
  Manure                               403          16          30         1        17
  Seeding                            10109         391         453        16       407
  Summerfallow & weed control         3858         149          71         2       152
  Transportation                      1535          59        2849        98       158
  Used by others                       246          10          40         1        11
          Total                      21095         816        6899       238      1054
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Mon Mar 28 22:03:18 1983

Farm No. 2

Page 1

Equipment		Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel							
Non-energy use		33					
Tractor, IHC 1256, 1968		2621	12.5	2.7			
Tractor, IHC 3588, 1979		8552	19.0	4.2			
Tractor, IHC 706-282, 1966		1786	7.3	1.6			
Tractor, IHC 706-310, 1967		1874	6.5	1.4			
Tractor, White 9700, 1982		200					
	Total	15066					
Gasoline							
Auger		208					
Car, Buick Skylark, 1975		718					
Car, Dodge Dart, 1971		1134			15.7	6.5	18
Car, Dodge K-car, 1981		1445			8.1	12.4	35
Car, Dodge(?) Coronet, 1975		1004					
Car, Toyota, 1971		513					
Combine, Cockshutt 545, 1966		1846					
Garden tractor		21					
Lawnmower		59					
Non-energy use		55					
Pump		12					
Supplied to others		328					
Swather, IHC 175, 1966		179					
Swather, White 6400, 1980		1083	12.3	2.7			
Tractor, IHC 350, 1958		596					
Truck, 3 ton, Dodge, 1975		2103			59.2	1.7	5
Truck, 3/4 ton, Dodge, 1979		3474			22.8	4.4	12
Truck, 4 ton, Chevrolet, 1965		1304					
Truck, Reo, 1948		375					
Van, Dodge, 1981		2262			18.8	5.3	15
	Total	18719					

Liquid Fuel Use by Operation, 1982

Mon Mar 28 22:03:18 1983 Farm No. 2 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Crop miscellaneous			9	0	0
Farmstead	116	4	101	3	8
Feed	3113	120	2121	73	194
Harvest & hauling	1805	70	4915	170	239
Land improvement	1203	47	12	0	47
Livestock miscellaneous	61	2	367	13	15
Manure	82	3	433	15	18
Seeding	2614	101	395	14	115
Summerfallow & weed control	6072	235			235
Transportation			10038	346	346
Used by others			328	11	11
Total	15066	583	18719	646	1229

The complete fuel log data for farm 3 is shown separately as Appendix A (which follows this section).

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 01:04:52 1983 Farm No. 4 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg	
Diesel fuel							
Irrigation equipment	358						
Non-energy use	43						
Supplied to others	110						
Tractor, AC 7040, 1975	8379	14.2	3.1				
Tractor, Case 970, 1973	2805	9.5	2.1				
Tractor, NH TR70, 1977	5537						
Total	17232						
Gasoline							
Auger	155						
Car, Buick, 1973	10						
Car, Ford, 1969	45						
Car, Ford, 1974	1227			12.5	8.0	23	
Car, Mazda, 1982 (blue)	580			1.7	59.7	168	Check data!
Car, Mazda, 1982 (red)	246						
Garden tractor	309						
Irrigation equipment	12						
Non-energy use	41						
Pump	12						
Sprayer	225						
Supplied to others	336						
Truck, 1/2 ton, Ford, 1978	4169			19.9	5.0	14	
Truck, 1/2 ton, Ford, 1980	926						
Truck, 3 ton, IHC, 1964	929						
Truck, 3 ton, IHC, 1967	736			18.1	5.5	16	
Total	9958						

```
              Liquid Fuel Use by Operation, 1982
Tue Mar 29 01:21:10 1983          Farm No. 4
                                                              Page 1
Operation
                                    Diesel Fuel           Gasoline       Total
                                     L        GJ        L        GJ       GJ
Crop miscellaneous                  388       15        16        1       16
Farmstead                           259       10       350       12       22
Feed                                663       26                          26
Harvest & hauling                  6414      248      1497       52      300
Land improvement                    347       13                          13
Manure                              108        4                           4
Seeding                            4661      180       363       13      193
Summerfallow & weed control        4282      166       268        9      175
Transportation                                        7128      246      246
Used by others                      110        4       336       12       16
        Total                     17232      667      9958      344     1010
```

```
      Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 02:10:01 1983             Farm No. 5                                  Page 1

Equipment                           Total                Fuel Use Rate
                                  Fuel Use
                                         L       L/h       gph   L/100km     km/L       mpg

Diesel fuel
  Supplied to others                    96
  Tractor, Case 1070, 1971            2483      12.2       2.7
  Tractor, Case 2390, 1981            8587      23.4       5.2

                          Total      11166

Gasoline
  Auger                                110
  Car, Dodge Dart, 1967                668                          12.7      7.9        22
  Car, Oldsmobile, 1979               1031                          14.0      7.2        20
  Garden tractor                        78
  Lawnmower                              3
  Non-energy use                       131
  Pump                                   4
  Supplied to others                   125
  Swather, MF 34, 1964                 191
  Tractor, Oliver S-88, 1956           549       8.6       1.9
  Truck, 1.5 ton, IHC, 1952            111                          39.4      2.5         7
  Truck, 1/2 ton, Ford, 1974          1365                          26.0      3.8        11
  Truck, 3 ton, Dodge 600, 1974       2061                          73.0      1.4         4

                          Total       6427
```

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                 Liquid Fuel Use by Operation: 1982
Tue Mar 29 02:18:51 1983                   Farm No. 5                                  Page 1
Operation
                                              Diesel Fuel          Gasoline      Total
                                                 L        GJ        L       GJ       GJ
Crop miscellaneous                             149         6       106       4        9
Farmstead                                                          307      11       11
Feed                                            66         3        33       1        4
Harvest & hauling                             3279       127      2016      70      196
Seeding                                       3484       135       665      23      158
Summerfallow & weed control                   4092       158        33       1      159
Transportation                                                    3142     108      108
Used by others                                  96         4       125       4        8
       Total                                 11166       432      6427     222      654
```

```
    Liquid  Fuel  Use  and  Fuel Use  Rate  by  Equipment,  1982

Fri Mar 25 03:48:31 1983                    Farm No. 6                                      Page 1

Equipment                                  Total                  Fuel Use Rate
                                         Fuel Use
                                             L        L/h       gph   L/100km      km/L       mpg

Diesel fuel
   Grain dryer, Carrol R, 1966            1075
   Non-energy use                           24
   Supplied to others                      100
   Tractor, Cockshutt 1850, 1971          1527       10.9       2.4
   Tractor, Deutz 1006, 1969              2939        7.2       1.6
   Tractor, Deutz 13006, 1974             3881       13.0       2.9
   Tractor, Massey 90, 1960                417        5.3       1.2
   Tractor, White 2-105                    928       15.0       3.3
   Tractor, White 2-135, 1980             9349       16.1       3.6

                              Total      20240

Gasoline
   Auger                                    53
   Boat                                     97
   Car, Chrysler, 1969                    1129                          22.2       4.5        13
   Car, Datsun, 1970                       607                           8.3      12.1        34
   Lawnmower                                47
   Non-energy use                           66
   Pump                                     94
   Supplied to others                      120
   Swather, CCIL 550, 1979                1001
   Tractor, Ford 9N, 1948                   90
   Tractor, MF 65, 1965                    526        8.9       2.0
   Truck, 1 ton, Chevrolet, 1958            86
   Truck, 1/2 ton, Chev, 1969             1735                          18.5       5.4        15
   Truck, 1/2 ton, Dodge, 1982             815                          21.0       4.8        13
   Truck, 3 ton, Chevrolet, 1960           522                          41.8       2.4         7
   Truck, 3 ton, Ford, 1964               1846                          36.7       2.7         8
   Truck, 3 ton, GMC, 1976                1458                          33.1       3.0         9
   Truck, 3/4 ton, Ford, 1980             5356                          21.3       4.7        13

                              Total      15648
```

Liquid Fuel Use by Operation, 1982

Fri Mar 25 04:00:32 1983 Farm No. 6 Page 1

Operation	Diesel Fuel		Gasoline		Total
	L	GJ	L	GJ	GJ
Farmstead	179	7	221	8	15
Feed	2357	91	872	30	121
Harvest & hauling	4628	179	3987	138	317
Harvest & hauling, custom	100	4			4
Land improvement	192	7			7
Livestock miscellaneous	106	4	20	1	5
Manure	485	19	457	16	35
Recreation			97	3	3
Seeding	6287	243	231	8	251
Summerfallow & weed control	5806	225	68	2	227
Transportation			9575	330	330
Used by others	100	4	120	4	8
Total	20240	783	15648	540	1323

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 03:15:34 1983 Farm No. 7 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	mph	L/100km	km/L	mpg
Diesel fuel						
Furnace	6					
Supplied to others	152					
Tractor, John Deere 1830, 1978	738	2.6	0.6			
Tractor, John Deere 4440, 1980	3106	9.7	2.1			
Tractor, John Deere 4630, 1978	6164	13.2	2.9			
Total	10166					
Gasoline						
Auger	183					
Boat	13					
Car, Buick, 1980	1679			16.2	6.2	17
Car, Chevrolet, 1974	2009			21.4	4.7	13
Car, Pontiac, 1979	1679			14.3	7.0	20
Garden tractor	20					
Lawnmower	229					
Non-energy use	105					
Pump	9					
Supplied to others	261					
Swather, MF 756, 1980	713					
Truck, 1 ton, Dodge, 1954	145					
Truck, 1/2 ton, GMC 1978	2152			13.4	7.5	21
Truck, 1/2 ton, GMC, 1974	1526			25.6	3.9	11
Truck, 1/2 ton, GMC, 1978	4504			18.6	5.4	15
Truck, 1/2 ton, GMC, 1982	2237			14.6	6.9	19
Truck, 3 ton, GMC, 1978	1235			50.5	2.0	6
Truck, tandem, GMC, 1974	633			41.0	2.4	7
Total	19332					

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              Liquid Fuel Use by Operation, 1982
Tue Mar 29 03:33:54 1983              Farm No. 7                         Page 1

Operation                                   Diesel Fuel           Gasoline      Total
                                              L        GJ        L       GJ       GJ

Farmstead                                   106         4      727       25       29
Feed                                         10         0      122        4        5
Harvest & hauling                          3367       130     1861       64      195
Recreation                                                      13        0        0
Seeding                                    2963       115      295       10      125
Summerfallow & weed control                3568       138                        138
Transportation                                               16053      554      554
Used by others                              152         6      261        9       15
       Total                              10166       393    19332      667     1060
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 04:27:55 1983

Farm No. 8

Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Backhoe, Case 580, 1979	625	5.7	1.2			
Non-energy use	24					
Tractor, Case 2670, 1979	610					
Tractor, Case 4690-1	6340	29.4	6.5			
Tractor, Case 4890-4, 1980	5722	28.2	6.2			
Tractor, IHC 1480-1, 1981	8324	25.2	5.4			
Tractor, IHC 1480-2, 1981	7560	26.6	5.9			
Tractor, IHC 1486, 1978	1007	10.7	2.3			
Tractor, IHC 3488, 1982	1601	12.8	2.8			
Tractor, Vers 1150-1, 1982	12393	43.6	9.6			
Tractor, Vers 1150-2, 1982	17515	37.6	8.3			
Truck, 1/2 ton, Volksw, 1980	1383			7.3	13.7	39
Truck, semi, Ford 9000, 1979	5087			71.9	1.4	4
Truck, tandem, IHC, 1981	4392			54.1	1.8	5
Total	72583					
Gasoline						
Auger	350					
Car, Chevrolet Z-28, 1983	705			4.5	22.0	62
Car, Ford LTD, 1979	1616			21.4	4.7	11
Car, Ford Meteor, 1976	737					
Car, Lincoln, 1979	2187			19.5	5.1	14
Car/truck ? (od.71000 @ 12/82)	548			17.8	5.6	16
Lawnmower, Case 646	187					
Non-energy use	209					
Pump	26					
Spray coupe, SC 115, 1979	857	6.7	1.5			
Supplied to others	1241					
Swather, IHC 4000, 1979	3085					
Tractor, IHC W4, 1945	224					
Tractor, IHC W6, 1945	559					
Tractor, John Deere A, 1945	267					
Truck, 1 ton, Chevrolet, 1978	1698			28.7	3.5	10
Truck, 1 ton, IHC 1310, 1970	762			54.1	1.8	5
Truck, 1/2 ton, Chev S10, 1982	1918			10.6	9.5	27
Truck, 1/2 ton, Chev, 1972	707					
Truck, 1/2 ton, Chev, 1978	1106			33.6	3.0	8
Truck, 1/2 ton, Ford, 1980	5149			23.7	4.2	12
Truck, 3 ton, Ford, 1962	711					
Truck, tandem, IHC 1810, 1978	2490					
Van, Ford 150, 1978	1457			34.1	2.9	8
Welder	42					
Total	28908					

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Liquid Fuel Use by Operation: 1982

Tue Mar 29 04:50:43 1983               Farm No. 8                          Page 1

Operation                               Diesel Fuel             Gasoline      Total
                                          L        GJ         L        GJ        GJ

Farmstead                                643        25      1102        38        63
Harvest & hauling                      27417      1061      7024       242      1303
Seeding                                32834      1271      1050        36      1307
Summerfallow & weed control            10196       395      1786        62       456
Transportation                          1493        58     16705       576       634
Used by others                                              1241        43        43
           Total                       72583      2809     28908       997      3806
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Fri Mar 25 17:11:31 1983 Farm No. 9 Page 1

Equipment		Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel							
Combine, CCIL M-103, 1964		673					
Non-energy use		8					
Tractor, Deutz 50, 1963		513					
Tractor, Deutz 7206, 1978		2027	5.6	1.2			
	Total	3221					
Gasoline							
Auger		50					
Bobcat		34					
Car, Ford Fairlane, 1968		156					
Car, Plymouth, 1970		6					
Car, Valiant (borrowed)		144			13.3	7.5	21
Lawnmower		29					
Seed cleaner		18					
Stacker		96					
Supplied to others		214					
Swather, Versatile 103, 1966		163					
Tractor, Ford 8N, 1949		67					
Truck, 1 ton, IHC, 1960		647			39.3	2.6	7
Truck, 1/2 ton, Fargo, 1968		250			26.9	3.7	10
Truck, 1/2 ton, GMC, 1976		2419			16.2	6.2	17
	Total	4293					

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                Liquid Fuel Use by Operation, 1982

Fri Mar 28 17:33:29 1983              Farm No. 9                            Page 1

Operation                               Diesel Fuel          Gasoline     Total
                                          L       GJ         L       GJ      GJ

Crop miscellaneous                        8        0                          0
Farmstead                                                  149        5       5
Feed                                    242        9       190        7      16
Harvest & hauling                       764       30       572       20      49
Land improvement                        393       15                         15
Manure                                   25        1        34        1       2
Seeding                                1237       48        43        1      49
Summerfallow & weed control             552       21                         21
Transportation                                            3091      107     107
Used by others                                             214        7       7
      Total                            3221      125      4293      148     273
```

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    Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Apr 12 16:14:27 1983                    Farm No. 10                                        Page 1

Equipment                                  Total                  Fuel Use Rate
                                         Fuel Use
                                             L        L/h      mph   L/100km      km/L      mpg

Diesel fuel
   Non-energy use                           94
   Tractor, Cockshutt 1800, 1966          1275        6.0      1.3
   Tractor, White 105, 1979               3566       11.5      2.5
   Tractor, White 135 (rented)             527
   Truck, IHC 4070a, 1977                 3884                         77.4       1.3        4

                               Total      9346

Gasoline
   Car, Dodge, 1979                        675                          6.1      16.4       46       check data
   Lawnmower                                 8
   Skidsteer loader L35, 1980             3189        8.1      1.8
   Supplied to others                       56
   Swather (rented)                         86
   Tractor, Cockshutt 1600, 1966           130        4.3      1.0
   Truck (rented)                          141
   Truck, 1/2 ton, Dodge, 1976            3056                         21.1       4.7       13
   Truck, 3 ton (rented)                    74
   Truck, 3/4 ton (rented)                 230

                               Total      7645
```

Liquid Fuel Use by Operation, 1982

Tue Apr 12 16:14:00 1983 Farm No. 10 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Farmstead	64	2	23	1	3
Feed	6852	265	1495	52	317
Harvest & hauling			153	5	5
Land improvement			77	3	3
Livestock miscellaneous	94	4	169	6	9
Manure	847	33	2129	73	106
Summerfallow & weed control	1489	58			58
Transportation			3543	122	122
Used by others			56	2	2
Total	9346	362	7645	264	625

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Apr 12 15:02:33 1983 Farm No. 11 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Tractor, Deutz 7006, 1971	3137	6.6	1.5			
Tractor, Ford 8N, 1960	129					
Truck, 1/2 ton, GMC, 1978	662			11.6	8.6	24
Total	3928					
Gasoline						
Auger	43					
Car, Ford Pinto, 1978	674			7.1	14.2	40
Combine, Case 1000, 19..	1007					
Non-energy use	12					
Tractor, Ford-Ferguson, 19..	123					
Truck, ... ton, IHC, 1966	873			33.8	3.0	8
Total	2732					

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                   Liquid Fuel Use by Operation, 1982
Tue Apr 12 15:32:47 1983           Farm No. 11
                                                                        Page 1
Operation
                                       Diesel Fuel             Gasoline      Total
                                        L        GJ          L        GJ      GJ

Farmstead                               25        1        252         9      10
Feed                                   103        4                            4
Harvest & hauling                                         1584        55      55
Land improvement                        22        1         68         2       3
Seeding                                674       26        154         5      31
Summerfallow & weed control           2382       92                           92
Transportation                         722       28        674        23      51
      Total                           3928      152       2732        94     246
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 07:30:14 1983 Farm No. 12 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Tractor, Deutz, 1982 (demo)	183	8.1	1.8			
Tractor, IHC 3388, 1982 (demo)	175	25.0	5.5			
Tractor, John Deere 2130, 1976	1132	6.2	1.4			
Tractor, John Deere 4230, 1974	5164	14.2	3.1			
Total	6654					
Gasoline						
Auger	38					
Car, Datsun, 19..	424			6.0	16.7	47
Car, Malibu, 1978	16					
Garden tractor	5					
Pump	37					
Swather, CCIL, 1966 (rented)	477					
Truck, 1.5 ton, GMC, 1954	231					
Truck, 1/2 ton, GMC, 1971	2021			24.9	4.0	11
Truck, 3 ton, GMC, 1964	566			43.0	2.3	7
Total	3815					

Liquid Fuel Use by Operation, 1982

Tue Mar 29 07:38:16 1983 Farm No. 12 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Crop miscellaneous	40	2	15	1	2
Farmstead	411	16	235	8	24
Feed	871	34	425	15	48
Harvest & hauling	1370	53	933	32	85
Land improvement			37	1	1
Manure	359	14			14
Seeding	2157	83	55	2	85
Summerfallow & weed control	1446	56	25	1	57
Transportation			2090	72	72
Total	6654	258	3815	132	389

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 21:35:34 1983

Farm No. 13

Page 1

Equipment		Total Fuel Use	Fuel Use Rate				
		L	L/h	mph	L/100km	km/L	mpg
Diesel fuel							
Car, Pontiac, 1981		85					
Combine, MF 760, 1976		309					
Crawler, John Deere 1010, 1961		119					
Tractor, John Deere 4020, 1965		1770					
Tractor, John Deere 4640, 1978		7228					
	Total	9511					
Gasoline							
Auger		23					
Swather, MF 655, 1976		89					
Tractor, Ford 9N, 1945		37					
Tractor, IHC M1 (rented)		374					
Tractor, IHC M2, 1950		394					
Tractor, MH 30, 1945		17					
Truck, 1 ton, GMC, 1966		193					
Truck, 1/2 ton, Chev, 1978		2094					
Truck, 3 ton, IHC, 1970		2268					
Truck, Mazda 1600, 1971		207					
	Total	5696					

Liquid Fuel Use by Operation, 1982

Tue Mar 29 21:35:03 1983 Farm No. 13 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Feed	423	16	203	7	23
Harvest & hauling	3702	143	2372	82	225
Livestock miscellaneous			77	3	3
Manure	257	10	226	8	18
Seeding	2043	79	420	14	94
Summerfallow & weed control	3001	116	153	5	121
Transportation	85	3	2245	77	81
Total	9511	368	5696	197	565

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Mar 29 23:52:16 1983 Farm No. 14 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Tractor, John Deere 4440, 1979	3584	14.4	3.2			
Tractor, John Deere 4640	11593	23.4	5.1			
Total	15177					
Gasoline						
Auger	202					
Car, Mercury, 1975	246			17.7	5.7	16
Car, Oldsmobile, 1982	86					
Garden tractor	45					
Lawnmower	25					
Non-energy use	21					
Rototiller	6					
Snowmobiles	49					
Supplied to others	105					
Tractor, MH 50, 1953	80	4.7	1.0			
Truck 1/2 ton, Chevrolet, 1982	1824			10.4	9.6	27
Truck, 1/2 ton, Chev S15, 1982	1499			8.6	11.6	33
Truck, 3 ton, Chevrolet, 1976	2037			36.6	2.7	8
Total	6225					

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            Liquid Fuel Use by Operation, 1982

Tue Mar 29 23:51:45 1983              Farm No. 14                                   Page 1

Operation                                          Diesel Fuel                  Gasoline     Total
                                                 L          GJ          L          GJ   .      GJ

Farmstead                                       75           3        233           8         11
Harvest & hauling                             4013         155       1835          63        219
Land improvement                                                      104           4          4
Recreation                                                             49           2          2
Seeding                                       3070         119        247    cat: can't open floow
        9        127
Summerfallow & weed control                   8019         310         63           2        313
Transportation                                                       3589         124        124
Used by others                                                        105           4          4
           Total                             15177         587       6225         215        802
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Wed Mar 30 01:42:00 1983 Farm No. 15 Page 1

Equipment		Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel							
Combine, MF 760, 1973		2489					
Combine, MF 760, 1978		2364					
Non-energy use		28					
Tractor, Case 830, 1964		1130					
Tractor, John Deere 4430, 1976		207					
Tractor, Versatile 145, 1970		7147	22.1	4.9			
Tractor, Versatile 850, 1975		25821	41.9	9.2			
Truck, tandem, Ford, 1971		4629					
	Total	43815					
Gasoline							
Auger		45					
Boat		216					
Garden tractor		40					
Non-energy use		124					
Pump		76					
Snowmobile		25					
Swather, CCIL, 1974		818					
Tractor, Massey 44, 1954		399					
Tractor, Massey 50, 1960		88					
Truck, 1/2 ton, Ford, 1973		3697			23.5	4.3	12
Truck, 1/2 ton, Ford, 1983		1178			12.9	7.7	22
Truck, 3/4 ton, Ford, 1974		4651			26.1	3.8	11
Truck, Ford 250, 1983		278			9.0	11.1	31
Welder		16					
	Total	11651					

Liquid Fuel Use by Operation, 1982

Wed Mar 30 01:41:51 1983 Farm No. 15 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Farmstead	397	15	302	10	26
Harvest & hauling	9948	385	1322	46	431
Land improvement	3544	137	26	1	138
Recreation			317	11	11
Seeding	14004	542	262	9	551
Summerfallow & weed control	15922	616	326	11	627
Transportation			9096	314	314
Total	43815	1696	11651	402	2098

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Wed Mar 30 01:14:18 1983 Farm No. 16 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Tractor, Case 4490, 1981	12407	23.9	5.3			
Tractor, John Deere 4020, 1970	890	7.5	1.7			
Tractor, John Deere 4430, 1976	2390	13.0	2.9			
Total	15687					
Gasoline						
Auger	32					
Car, Citation, 1980	2595					
Garden tractor	217					
Non-energy use	100					
Swather, IHC 175, 1970	60					
Truck, 1/2 ton, Chev, 1966	313			18.7	5.4	15
Truck, 2.5 ton, GMC, 1956	343			69.4	1.4	4
Truck, 3 ton, GMC, 1975	1703			61.8	1.6	5
Truck, Ford F-150, 1981	926			30.0	3.3	9
Truck, GMC, 1982	50					
Total	6339					

```
                 Liquid Fuel Use by Operation, 1982
Wed Mar 30 01:11:53 1983              Farm No. 16                                 Page 1

Operation                                   Diesel Fuel                Gasoline       Total
                                            L         GJ            L        GJ          GJ

Crop miscellaneous                        320         12           96         3          16
Farmstead                                 213          8          284        10          18
Harvest & hauling                        3054        118         1833        63         181
Seeding                                  2640        102          101         3         106
Summerfallow & weed control              9460        366          108         4         370
Transportation                                                   3917       135         135
       Total                            15687        607         6339       219         826
```

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           Liquid Fuel Use and Fuel Use Rate by Equipment, 1982
Wed Mar 30 03:06:35 1983                Farm No. 17                                   Page 1
Equipment                                    Total             Fuel Use Rate
                                           Fuel Use
                                                  L       L/h       mph  L/100km      km/L       mpg

Diesel fuel
  Supplied to others                            287
  Tractor, IHC 1086, 1979                      4005      14.0       3.1
  Tractor, IHC 624, 1966                        741       3.6       0.8

                               Total           5033

Gasoline
  Auger                                          68
  Car, Cordoba, 1979                             39
  Combine, IHC 715, 1975                       1598
  Lawnmower                                     124
  Supplied to others                            114
  Truck, 1/2 ton, Ford 100, 1979               1262                       16.2       6.2        17
  Truck, 3 ton, Ford 600, 1979                 1136                       43.3       2.3         7
  Truck, Ford, 1970                             127                       77.4       1.3         4

                               Total           4468
```

Liquid Fuel Use by Operation, 1982

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Wed Mar 30 03:06:34 1983                Farm No. 17                                     Page 1

Operation                                   Diesel Fuel                Gasoline      Total
                                           L          GJ          L          GJ          GJ

Farmstead                                                        155          5           5
Feed                                     370          14          56          2          16
Harvest & hauling                        355          14        2671         92         106
Seeding                                 1386          54         428         15          68
Summerfallow & weed control             2635         102                                102
Transportation                                                  1044         36          36
Used by others                           287          11         114          4          15
       Total                            5033         195        4468        154         349
```

cat mouse | cat mouse

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 Liquid Fuel Use and Fuel Use Rate by Equipment, 1982
 Wed Mar 30 05:18:17 1983               Farm No. 18                              Page 1

 Equipment                                     Total              Fuel Use Rate
                                            Fuel Use
                                                   L      L/h      gph  L/100km     km/L      mpg

 Diesel fuel
    Combine, MF 750, 1979                       2970
    Tractor, Case 1175, 1978                    6510
    Tractor, John Deere 4020, 1977              2110
    Tractor, John Deere 4840, 1980             11583

                                  Total        23173

 Gasoline
    Car, Oldsmobile, 1981                       6137
    Truck, 1/2 ton, Chev, 1978                 12500
    Truck, 1/2 ton, Chev, 1980                  6250
    Truck, 3 ton, GMC 6500, 1974                1738
    Truck, 3 ton, GMC 6500, 1981                2655

                                  Total        29280
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```
cat done | cat done

        Liquid Fuel Use by Operation, 1982
Wed Mar 30 05:28:13 1983              Farm No. 18                                          Page 1
Operation
                                          Diesel Fuel                 Gasoline         Total
                                         L           GJ           L          GJ           GJ
Field operations                    20203          782                                   782
Harvest & hauling                    2970          115         4393         152          266
Transportation                                                24887         859          859
            Total                   23173          897        29280        1010         1907
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Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Wed Mar 30 05:54:56 1983 Farm No. 19 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Non-energy use	30					
Tractor, Cockshutt 1755, 1968	1079	6.2	1.4			
Tractor, Cockshutt 1850, 1964	956	0.4	0.1			
Total	2065					
Gasoline						
Auger	3					
Car, Toyota, 1976	547			12.6	8.0	22
Lawnmower	12					
Rototiller	2					
Supplied to others	8					
Swather, Versatile 400, 1969	515					
Truck, 1/2 ton, Ford, 1980	2706			2.7	36.7	104
Truck, 2 ton, Chevrolet, 1977	361			171.1	0.6	2
Truck, Toyota, 1976	1430			21.8	4.6	13
Total	5584					

Liquid Fuel Use by Operation, 1982

Wed Mar 30 05:54:41 1983 Farm No. 19 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Farmstead	2	0	14	0	1
Feed	1404	54	735	25	80
Harvest & hauling			429	15	15
Livestock miscellaneous			35	1	1
Seeding	392	15			15
Summerfallow & weed control	239	9			9
Transportation	28	1	4363	151	152
Used by others			8	0	0
Total	2065	80	5584	193	273

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Wed Mar 30 19:16:27 1983 Farm No. 20 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	l/100km	km/L	mpg
Diesel fuel						
Combine, NH TR85, 1980	360					
Tractor, IHC 1066, 1976	9989	18.3	4.0			
Tractor, IHC 660, 1958	1845					
Tractor, IHC W09, 1951	50					
Tractor, John Deere 4010, 1962	2188					
Total	14432					
Gasoline						
Auger	118					
Car, Chrysler, 1972	7792			8.7	11.5	33
Combine, MF 92, 1959	51					
Garden tractor	239	3.0	0.7			
Non-energy use	142					
Supplied to others	73					
Swather, MF 655, 1978	113					
Truck (?), GMC, (mi?)	353					
Truck(?), GM, (mi?)	969			155.4	0.6	2
Truck, 1 ton, IHC, 1950	70					
Truck, 1/2 ton, Dodge, 1964	1328			20.7	4.8	14
Truck, 1/2 ton, Ford, 1966	60					
Truck, 2 ton, Chevrolet, 1960	258					
Truck, 3 ton, Chevrolet, 1981	2059					
Total	13625					

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            Liquid Fuel Use by Operation, 1982
Wed Mar 30 19:16:10 1983               Farm No. 20                             Page 1
Operation                                   Diesel Fuel              Gasoline        Total
                                            L          GJ          L         GJ        GJ
Farmstead                                 146          6         451        16        21
Harvest & hauling                        4163        161        2402        83       244
Seeding                                  2723        105         433        15       120
Summerfallow & weed control              7400        286         117         4       290
Transportation                                                 10149       350       350
Used by others                                                    73         3         3
        Total                           14432        559       13625       470      1029
```

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Tue Apr 12 13:19:54 1983 | Farm No. 21 | Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	mph	L/100km	km/L	mpg
Diesel fuel						
Non-energy use	7					
Tractor, Case 1070, 1977	314	8.2	1.8			
Tractor, Case 1490, 1981	844	5.5	1.2			
Tractor, Case 2390, 1981	12439	23.8	5.2			
Tractor, John Deere 4020, 1967	3671	7.7	1.7			
Tractor, White 2-105, 1975	198					
Tractor, White 2-150, 1976	3277	18.3	4.0			
Uniloader, Case U845, 1982	65					
Total	20815					
Gasoline						
Auger	28					
Combine, MF 510, 1975	1669					
Garden tractor	46					
Lawnmower	18					
Loader, Bobcat 720, 1980	202	10.1	2.2			
Non-energy use	169					
Power generator	15					
Pump	14					
Rototiller	17					
Snowmobile	41					
Supplied to others	1207					
Swather, Co-op, 1980	55					
Swather, John Deere 800, 1980	73					
Swather, White 504, 1980	908					
Truck, 1/2 ton, Chev 4x4, 1980	1196			27.8	3.6	10
Truck, 1/2 ton, Ford 150, 1978	3770			20.2	4.9	14
Truck, 3 ton, Chev 60, 1980	863			54.4	1.8	5
Truck, 3 ton, IHC 1600, 1973	2063			55.3	1.8	5
Truck, 3/4 ton, Ford 250, 1976	353			25.1	4.0	11
Total	12706					

Liquid Fuel Use by Operation, 1982

Tue Apr 12 14:23:36 1983 Farm No. 21 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Farmstead	94	4	250	9	12
Feed	4343	168	1608	55	224
Harvest & hauling	2033	79	3612	125	203
Land improvement	319	12			12
Livestock miscellaneous			5	0	0
Manure	1627	63	202	7	70
Power generation	100	4	15	1	4
Recreation			41	1	1
Seeding	5446	211	244	8	219
Summerfallow & weed control	6851	265			265
Transportation			5522	191	191
Used by others			1207	42	42
Total	20815	806	12706	438	1244

APPENDIX A

Appendix A. Farm Fuel Meter and Log Sheet Analyses

Work in progress

Example of preliminary analyses of the complete fuel meter and fuel log data from one farm (#3): The description of the farm and the 1981 estimated distribution of energy is included for general comparison.

The complete analyses of the data will be presented in a separate report planned for later in 1983, once various discrepancies in fuel use records have been reconciled (in progress).

This final report will plot fuel use:

- diesel fuel use per month (graph)
- gasoline use per month (graph)
- fuel use per unit or product
- other methods of examining and comparing the data (see previous discussion).

P. 1

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                    Farm Fuel Log Legend
Mon Mar 28 23:36:47 1983                                          Page 1
Farm    Eqpt_ID          Eqpt_Description                  Meter_Unit
     3  1850             Tractor, Cockshutt 1850, 1967     h
     3  stod             Supplied to others                h
     3  white            Tractor, White 4-150, 1975        h
     3  3/4t             Truck, 3/4 ton, Chev, 1975        mi
     3  big t            Truck, 4 ton, Ford, 1964          mi
     3  boat             Boat                              h
     3  car              Car, Mercury, 1981                km
     3  courier          Truck, 1/2 ton, Ford, 1980        km
     3  gard t           Garden tractor                    h
     3  auger            Auger                             h
     3  stog             Supplied to others                h
     3  non-eng          Non-energy use                    h
Op_Type        Op_Description
s              Seeding
swc            Summerfallow & weed control
h              Harvest & hauling
li             Land improvement
fs             Farmstead
cm             Crop miscellaneous
t              Transportation
f              Feed
m              Manure
lm             Livestock miscellaneous
r              Recreation
s-c            Seeding, custom
swc-c          Summerfallow & weed control, custom
h-c            Harvest & hauling, custom
power          Power generation
o              Used by others
fo             Field operations
Fuel_Type    Fuel_Description
d            Diesel fuel
g            Gasoline
```

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final

Farm Fuel Log Detail Report

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Sat Mar 26 04:52:55 1983                  Year 1982 Farm 3 Fuel Type d                              Page 1

 Equipment  Day  Mon  St. Meter  End Meter  Job    Clock Fuel Use    L/h      mph    L/100km    km/L     mpg

                                                     h
      1850   31    7        842        855   f      13      155     11.9      2.6

                                 Total Job   f      13      155     11.9      2.6

              3    9        855        868   h      13       94      7.2      1.6
             21    9        868        875   h       7       40      5.7      1.3
             25   10        888        892   h       4       47     11.7      2.6

                                 Total Job   h      24      181      7.5      1.7

             27    5          0          0  11       0       85
             19   10        875        888  11      13       70      5.4      1.2

                                 Total Job  11      13      155      5.4      1.2

                          Total       1850          50      491      8.1      1.8

                                                     h
      stad   27    8          0          0   o       0      141
             22    9          0          0   o       0      129
             23    9          0          0   o       0      166
             30    9          0          0   o       0      120

                                 Total Job   o       0      556

                          Total       stad           0      556

                                                     h
     white   21    7       2992       2993   f       1        7      7.0      1.5
             23    7       3001       3009   f       8       59      7.4      1.6

                                 Total Job   f       9       66      7.3      1.6

             19    8       3035       3052   h      17      228     13.4      3.0
             24    8       3052       3058   h       6       85     14.2      3.1
             27    8       3068       3073   h       5       86     17.2      3.8
             28    8       3073       3081   h       8      111     13.9      3.1
              2    9       3081       3097   h      16      285     17.8      3.9
              3    9       3097       3109   h      12      191     15.9      3.5
              4    9       3109       3120   h      11      235     21.4      4.7
              8    9       3120       3134   h      14      271     19.4      4.3
              9    9       3134       3151   h      17      313     18.4      4.1
             11    9       3151       3164   h      13      262     20.2      4.4
             12    9       3164       3179   h      15      300     20.0      4.4
             17    9       3179       3200   h      21      300     14.3      3.1
             19    9       3200       3208   h       8      122     15.2      3.4
             22    9       3208       3218   h      10      194     19.4      4.3
```

Farm Fuel Log Detail Report

Sat Mar 26 04:52:55 1983

Year 1982 Farm 3 Fuel Type d

Equipment	Day	Mon	St. Meter	End Meter	Job	Clock	Fuel Use	L/h	gph	L/100km	km/L	mpg
	23	9	3218	3227	h	9	120	13.3	2.9			
	24	9	3227	3241	h	14	310	22.1	4.9			
	30	9	3241	3250	h	9	171	19.0	4.2			
				Total Job	h	205	3584	17.5	3.9			
	1	5	2655	2668	11	13	200	15.4	3.4			
	10	5	2737	2742	11	5	327	65.4	14.4			
	8	6	2867	2875	11	8	24	3.0	0.7			
	28	7	3013	3017	11	4	91	22.7	5.0			
	27	8	3058	3068	11	10	172	17.2	3.8			
				Total Job	11	40	814	20.3	4.5			
	28	4	2645	2655	s	10	450	45.0	9.9			
	11	5	2742	2747	s	5	161	32.2	7.1			
	11	5	2747	2755	s	8	212	26.5	5.8			
	13	5	2755	2767	s	12	275	22.9	5.0			
	16	5	2767	2783	s	16	299	18.7	4.1			
	17	5	2783	2792	s	9	217	24.1	5.3			
	19	5	2792	2803	s	11	332	30.2	6.6			
	22	5	2803	2812	s	9	214	23.8	5.2			
	25	5	2812	2826	s	14	288	20.6	4.5			
	25	5	2826	2830	s	4	151	37.7	8.3			
	27	5	2830	2837	s	7	209	29.9	6.6			
	1	6	2837	2844	s	7	179	25.6	5.6			
	2	6	2844	2851	s	7	211	30.1	6.6			
	4	6	2851	2860	s	9	263	29.2	6.4			
	7	6	2865	2867	s	2	165	82.5	18.2			
	8	6	2860	2865	s	5	94	18.8	4.1			
	8	6	2875	2887	s	12	350	29.2	6.4			
	10	6	2887	2891	s	4	100	25.0	5.5			
	10	6	2891	2893	s	2	52	26.0	5.7			
	13	6	2893	2908	s	15	280	18.7	4.1			
	17	6	2908	2923	s	15	177	11.8	2.6			
	18	6	2923	2932	s	9	199	22.1	4.9			
	21	6	2932	2938	s	6	168	28.0	6.2			
	22	6	2938	2946	s	8	178	22.2	4.9			
	11	10	3277	3283	s	6	220	36.7	8.1			
	16	10	3306	3315	s	9	270	30.0	6.6			
	18	10	3315	3324	s	9	279	31.0	6.8			
				Total Job	s	230	5993	26.1	5.7			
	3	5	2668	2680	s-c	12	344	28.7	6.3			
	3	5	2680	2688	s-c	8	237	29.6	6.5			
	5	5	2688	2692	s-c	4	236	59.0	13.0			
	5	5	2692	2707	s-c	15	324	21.6	4.8			
	6	5	2707	2718	s-c	11	334	30.4	6.7			
	7	5	2718	2727	s-c	9	255	28.3	6.2			
	9	5	2727	2737	s-c	10	129	12.9	2.8			

Farm Fuel Log Detail Report

Sat Mar 26 04:52:55 1983 | Year 1982 Farm 3 Fuel Type d | Page 3

Equipment	Day	Mon	St. Meter	End Meter	Job	Clock	Fuel Use	L/h	mph	L/100km	km/L	mpg
				Total Job	s-c	69	1859	26.9	5.9			
	23	6	2946	2956	swc	10	210	21.0	4.6			
	6	7	2956	2971	swc	15	229	15.3	3.4			
	10	7	2971	2983	swc	12	267	22.2	4.9			
	11	7	2983	2992	swc	9	238	26.4	5.8			
	21	7	2993	3001	swc	8	59	7.4	1.6			
	28	7	3009	3013	swc	4	90	22.5	5.0			
	29	7	3017	3026	swc	9	279	31.0	6.8			
	13	8	3026	3035	swc	9	266	29.6	6.5			
	13	10	3283	3288	swc	5	112	22.4	4.9			
	19	10	3324	3330	swc	6	292	48.7	10.7			
	20	10	3330	3340	swc	10	80	8.0	1.8			
	22	10	3340	3350	swc	10	300	30.0	6.6			
	28	10	3350	3378	swc	28	359	12.8	2.8			
				Total Job	swc	135	2781	20.6	4.5			
	8	10	3250	3277	swc-c	27	771	28.6	6.3			
	15	10	3288	3306	swc-c	18	544	30.2	6.7			
				Total Job	swc-c	45	1315	29.2	6.4			
			Total	white		733	16412	22.4	4.9			
				Fuel Total			17459					

Farm Fuel Log Detail Report

Sat Mar 26 04:52:55 1983 Year 1982 Farm 3 Fuel Type d

Equipment	Day	Mon	St. Meter	End Meter	Job	Clock	Fuel Use	L/h	mph	L/100km	km/L	mpg
						mi						
3/4t	31	7	74635	74760	f	125	70			34.8	2.9	8
	6	8	74760	74864	f	104	122			72.9	1.4	4
	26	10	77260	77370	f	110	67			37.9	2.6	7
	2	11	77480	77707	f	227	130			35.6	2.8	8
	5	11	77707	77853	f	146	127			54.1	1.8	5
	15	11	77853	78022	f	169	65			23.9	4.2	12
				Total Job	f	881	581			41.0	2.4	7
	12	9	75823	75910	h	87	120			85.7	1.2	3
	26	10	77370	77480	h	110	67			37.9	2.6	7
	16	11	78022	78043	h	21	87			257.5	0.4	1
				Total Job	h	218	274			78.1	1.3	4
	14	6	73433	73489	s	56	36			40.0	2.5	7
	17	6	73489	73611	s	122	70			35.7	2.8	8
				Total Job	s	178	106			37.0	2.7	8
	28	4	72100	72213	t	113	102			56.1	1.8	5
	3	5	72213	72295	t	82	62			47.0	2.1	6
	5	5	72295	72425	t	130	72			34.4	2.9	8
	6	5	72425	72507	t	82	41			31.1	3.2	9
	9	5	72507	72610	t	103	60			36.2	2.8	8
	15	5	72610	72652	t	42	40			59.2	1.7	5
	21	5	72652	72760	t	108	74			42.6	2.3	7
	26	5	72760	72871	t	111	65			36.4	2.7	8
	26	5	72871	72932	t	61	22			22.4	4.5	13
	31	5	72932	73039	t	107	69			40.1	2.5	7
	4	6	73039	73153	t	114	64			34.9	2.9	8
	8	6	73153	73306	t	153	68			27.6	3.6	10
	12	6	73306	73433	t	127	77			37.7	2.7	7
	22	6	73611	73690	t	79	44			34.6	2.9	8
	23	6	73690	73832	t	142	62			27.1	3.7	10
	25	6	73832	73900	t	68	70			64.0	1.6	4
	27	6	73900	73988	t	88	43			30.4	3.3	9
	5	7	73988	74097	t	109	60			34.2	2.9	8
	15	7	74097	74341	t	244	120			30.6	3.3	9
	21	7	74341	74500	t	159	120			46.9	2.1	6
	29	7	74500	74635	t	135	148			68.1	1.5	4
	8	8	74864	74995	t	131	124			58.8	1.7	5
	14	8	74995	75252	t	257	136			32.9	3.0	9
	21	8	75252	75432	t	180	70			24.2	4.1	12
	25	8	75432	75630	t	198	116			36.4	2.7	8
	9	9	75630	75823	t	193	61			19.6	5.1	14
	16	9	75910	76164	t	254	76			18.6	5.4	15
	21	9	76164	76375	t	211	127			37.4	2.7	8
	22	9	76375	76475	t	100	50			31.1	3.2	9

Farm Fuel Log Detail Report

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Equipment	Day	Mon	St. Meter	End Meter	Job	Clock	Fuel Use	L/h	kph	L/100km	km/L	mpg
	1	10	76475	76766	t	291	132			28.2	3.5	10
	6	10	76766	77000	t	234	86			22.8	4.4	12
	11	10	77000	77024	t	24	133			344.4	0.3	1
	22	10	77024	77260	t	236	133			35.0	2.9	8
	4	12	78043	78460	t	417	148			22.1	4.5	13
	8	12	78460	78558	t	98	73			46.3	2.2	6
	28	12	78558	79146	t	588	386			40.8	2.5	7
				Total Job	t	5769	3334			35.9	2.8	8
			Total	3/4t		7046	4295			37.9	2.6	7
						h						
auger	8	9	0	0	h	0	32					
	11	9	0	0	h	0	10					
	11	9	0	0	h	0	10					
	21	9	0	0	h	0	10					
	22	9	0	0	h	0	10					
				Total Job	h	0	72					
			Total	auger		0	72					
						mi						
big t	22	9	97205	97262	cm	57	87			94.9	1.1	3
				Total Job	cm	57	87			94.9	1.1	3
	3	6	96816	96870	h	54	32			36.8	2.7	8
	28	7	96923	96949	h	26	27			64.5	1.5	4
	27	8	96949	96975	h	26	42			100.4	1.0	3
	8	9	96975	97015	h	40	88			136.7	0.7	2
	10	9	97015	97067	h	52	63			75.3	1.3	4
	11	9	97067	97107	h	40	33			51.3	2.0	5
	21	9	97107	97117	h	10	23			142.9	0.7	2
	21	9	97117	97148	h	31	21			42.1	2.4	7
	22	9	97148	97205	h	57	139			151.6	0.7	2
	23	9	97262	97328	h	66	42			39.5	2.5	7
	22	10	97328	97378	h	50	148			184.0	0.5	2
				Total Job	h	452	658			90.5	1.1	3
	24	5	96780	96816	s	36	49			84.6	1.2	3
	13	6	96870	96923	s	53	47			53.1	1.8	5
				Total Job	s	89	96			67.0	1.5	4
			Total	big t		598	841			87.4	1.1	3
						h						

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                              Farm Fuel Log Detail Report
 Sat Mar 26 04:52:55 1983                  Year 1982 Farm 3 Fuel Type g                                  Page 6

      Equipment  Day  Mon  St. Meter  End Meter  Job   Clock Fuel Use     L/h      gph  L/100km     km/L     mpg

           boat   31    7          0          0   r        0      41

                                      Total Job   r        0      41

                              Total        boat            0      41

                                                          km
            car    2    5       3800       4091   t      291      51                       17.5      5.7      16
                   6    5       4091       4605   t      514      63                       12.3      8.2      23
                   6    5       4605       4816   t      211      41                       19.4      5.1      15
                  30    5       4816       5561   t      745      55                        7.4     13.5      38
                  10    6       5561       5867   t      306      59                       19.3      5.2      15
                  16    6       5867       6291   t      424      58                       13.7      7.3      21
                  28    6       6291       6689   t      398      65                       16.3      6.1      17
                  28    6       6689       7036   t      347      42                       12.1      8.3      23
                  13    7       7036       8374   t     1338      79                        5.9     16.9      48
                  18    7       8374       9461   t     1087      66                        6.1     16.5      46
                  21    7       9461      10070   t      609      57                        9.4     10.7      30
                   8    8      10070      10682   t      612      60                        9.8     10.2      29
                  11    8      10682      11100   t      418      60                       14.4      7.0      20
                   2    9      11100      13097   t     1997      47                        2.4     42.5     120
                   7    9      13097      13501   t      404      73                       18.1      5.5      16
                  29    9      13501      14358   t      857      60                        7.0     14.3      40
                   9   10      14358      14777   t      419      67                       16.0      6.3      18
                  24   10      14777      15268   t      491      70                       14.3      7.0      20
                  12   11      15268      16648   t     1380      62                        4.5     22.3      63
                   1   12      16648      18866   t     2218      70                        3.2     31.7      89
                   9   12      18866      19240   t      374      77                       20.6      4.9      14

                                      Total Job   t    15440    1282                        8.3     12.0      34

                              Total         car        15440    1282                        8.3     12.0      34

                                                          km
        courier   14    5          0          0   t        0     100
                  13    9          0          0   t        0      90
                  24    9          0          0   t        0      70

                                      Total Job   t        0     260

                              Total     courier            0     260

                                                          h
         gard t   15    6          0          0   fs       0      11
                  21    6          0          0   fs       0      22
                  24    7          0          0   fs       0      20
                  31    7          0          0   fs       0      20
                   7    9          0          0   fs       0      16
```

```
                              Farm Fuel Log Detail Report
 Sat Mar 26 04:52:55 1983                   Year 1982 Farm 3 Fuel Type g                                Page 7
     Equipment  Day  Mon  St. Meter  End Meter  Job    Clock Fuel Use       L/h        gph   L/100km      km/L       mpg
                 24    9          0          0  fs         0       21
                                     Total Job  fs         0      110
                            Total       gard t             0      110
                                                           h
       non-eng   14    5          0          0  cm         0       20
                                     Total Job  cm         0       20
                            Total      non-eng             0       20
                                                           h
          stog   12    6          0          0  o          0       40
                 22    6          0          0  o          0       42
                 28    9          0          0  o          0       66
                 10   10          0          0  o          0       27
                 10   10          0          0  o          0       27
                                     Total Job  o          0      202
                            Total         stog             0      202
                                   Fuel Total                    7123
```

FARM 3

FARM INVENTORY: YEAR 1981
REGION: EAST CENTRAL
SOIL ZONE: DARK BROWN
SOIL TYPE: ASQUITH LIGHT LOAM
TOPOGRAPHY: GENTLY ROLLING
TOTAL AREA: 1600 ACRES 648 HECTARES
CULTIVATED AREA: 1225 ACRES 496 HECTARES

	ANIMAL	NUMBER
TOTAL LIVESTOCK:	COWS	5

	ANIMAL	NUMBER
BREEDING STOCK:	COWS	5

	TYPE	YEAR BUILT	HEATED AREA
HOMES:	FARM HOME	1976	1408 SF 131 m^2

Crop Production: A three-year crop rotation is practiced by this farmer with the amount of stubble cropped dependent on spring moisture conditions.

The principal crops grown include: wheat and barley.

The tillage and seeding operations for crops on stubble include:

- 2 x fall deep tillage cultivation.
- seeding with a hoe drill.
- 2 x harrow.
- post-emergence spraying.

For crops grown on summerfallow:

- deep tillage cultivation.
- seeding with hoe drill.
- post-emergence spraying.

Summerfallow operations:

- 5 x deep tillage cultivation.

Fertilizer is applied according to soil test results.

Livestock Operation:

A herd of five cows is maintained for children's 4H projects. Feed is purchased. Bedding and hay is custom baled.

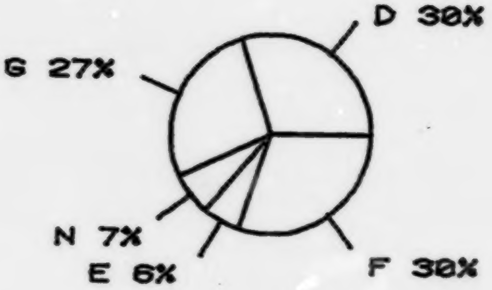
SPECIFIC RECOMMENDATIONS FOR ENERGY CONSERVATION

1. Test "Gear-up: throttle-down" practices.
2. Monitor feasibility of snow management.
3. Consider energy effectiveness of vehicle propane conversion.
4. Arrange an energy audit of the shop by the Office of Energy Conservation Energy Bus.

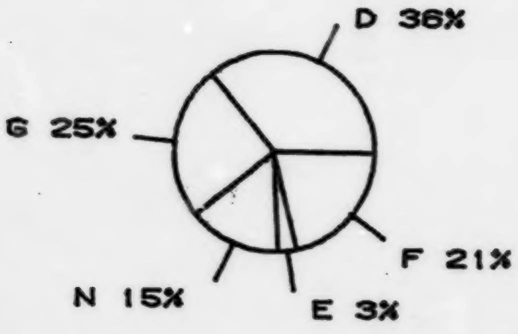
FARMER'S ESTIMATED DISTRIBUTION

Year 1980 Farm No. 3   Energy Cost $ 9,001   Total Expenses $ 34,503

Energy Cost By Fuel

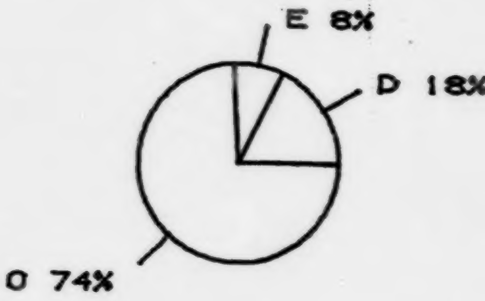


D = Diesel
G = Gasoline
H = Heating Oil
P = Propane
N = Natural Gas
W = Wood
E = Electricity
F = Fertilizer



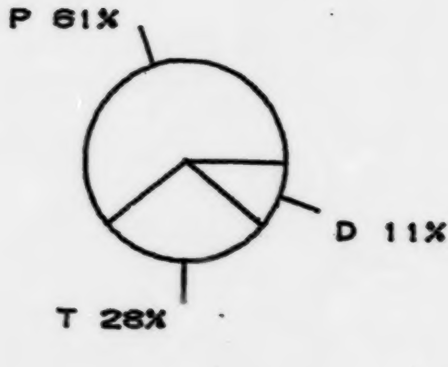
Energy Content
By Fuel

Energy Cost As Percentage
Of Total Expenses



D = Direct Energy
E = Embodied Energy
O = Other

P = Production
T = Transportation
D = Domestic



Energy Cost
By Sector

APPENDIX B

Liquid Fuel Use and Fuel Use Rate by Equipment, 1982

Sat Mar 26 04:57:52 1983 Farm No. 3 Page 1

Equipment	Total Fuel Use L	Fuel Use Rate L/h	gph	L/100km	km/L	mpg
Diesel fuel						
Supplied to others	556					
Tractor, Cockshutt 1850, 1967	491	8.1	1.8			
Tractor, White 4-150, 1975	16412	22.4	4.9			
Total	17459					
Gasoline						
Auger	72					
Boat	41					
Car, Mercury, 1981	1282			8.3	12.0	34
Garden tractor	110					
Non-energy use	20					
Supplied to others	202					
Truck, 1/2 ton, Ford, 1980	260					
Truck, 3/4 ton, Chev, 1975	4295			37.9	2.6	7
Truck, 4 ton, Ford, 1964	841			87.4	1.1	3
Total	7123					

```
                    Liquid Fuel Use by Operation, 1982
Sat Mar 26 05:09:50 1983                         Farm No. 3                                  Page 1
Operation                                              Diesel Fuel              Gasoline     Total
                                                      L          GJ        L          GJ        GJ

Crop miscellaneous                                                        107          4         4
Farmstead                                                                 110          4         4
Feed                                                221           9       581         20        29
Harvest & hauling                                  3765         146      1004         35       180
Land improvement                                    969          38                             38
Recreation                                                                 41          1         1
Seeding                                            5993         232       202          7       239
Seeding, custom                                    1859          72                             72
Summerfallow & weed control                        2781         108                            108
Summerfallow & weed control, custom                1315          51                             51
Transportation                                                           4876        168       168
Used by others                                      556          22       202          7        28
          Total                                   17459         676      7123        246       921
```

APPENDIX D

```
Use of Diesel fuel in 1982, by 10-Day Period
Sat Mar 26 05:13:04 1983          Farm No. 3                    Page 1
     Period     Litres

         12        450
         13       2386
         14       1496
         15        947
         16       1438
         17        656
         18        556
         19        229
         20        505
         21        585
         22        155
         23        266
         24        823
         25       1076
         26       1175
         27       1081
         28        291
         29       1917
         30       1068
         31        359
```

Liquid Fuel Use by Operation, 1982

Sat Mar 26 05:09:50 1983 Farm No. 3 Page 1

Operation	Diesel Fuel L	Diesel Fuel GJ	Gasoline L	Gasoline GJ	Total GJ
Crop miscellaneous			107	4	4
Farmstead			110	4	4
Feed	221	9	581	20	29
Harvest & hauling	3765	146	1004	35	180
Land improvement	969	38			38
Recreation			41	1	1
Seeding	5993	232	202	7	239
Seeding, custom	1859	72			72
Summerfallow & weed control	2781	108			108
Summerfallow & weed control, custom	1315	51			51
Transportation			4876	168	168
Used by others	556	22	202	7	28
Total	17459	676	7123	246	921

```
Use of Diesel fuel in 1982, by 10-Day Period

Sat Mar 26 05:13:04 1983          Farm No. 3                    Page 1

     Period     Litres

         12        450
         13       2386
         14       1496
         15        947
         16       1438
         17        656
         18        556
         19        229
         20        505
         21        585
         22        155
         23        266
         24        823
         25       1076
         26       1175
         27       1081
         28        291
         29       1917
         30       1068
         31        359
```

```
Use of Gasoline in 1982, by 10-Day Period

Sat Mar 26 05:13:04 1983          Farm No. 3                    Page 2

   Period    Litres

     12        102
     13        390
     14        160
     15        265
     16        292
     17        339
     18        390
     19         60
     20        265
     21        372
     22        437
     23        196
     24        228
     25        256
     26        463
     27        666
     28        278
     29        254
     30        485
     31        257
     32        214
     34        218
     35        150
     37        386
```

Equipment Fuel Use by Month, 1982

Tue Apr 12 16:40:46 1983

Farm No. 3

Equipment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Supplied to others	0	0	0	0	0	0	0	141	415	0	0	0
Tractor, Cockshutt 1850, 1967	0	0	0	0	85	0	155	0	134	117	0	0
Tractor, White 4-150, 1975	0	0	0	450	4744	2650	1319	948	3074	3227	0	0
Auger	0	0	0	0	0	0	0	0	72	0	0	0
Boat	0	0	0	0	0	0	41	0	0	0	0	0
Car, Mercury, 1981	0	0	0	0	210	224	202	120	180	137	62	147
Garden tractor	0	0	0	0	0	33	40	0	37	0	0	0
Non-energy use	0	0	0	0	20	0	0	0	0	0	0	0
Supplied to others	0	0	0	0	0	82	0	0	66	54	0	0
Truck, 1/2 ton, Ford, 1980	0	0	0	0	100	0	0	0	160	0	0	0
Truck, 3/4 ton, Chev, 1975	0	0	0	102	505	534	518	568	434	618	409	607
Truck, 4 ton, Ford, 1964	0	0	0	0	49	79	27	42	496	148	0	0
Total	0	0	0	552	5713	3602	2302	1819	5068	4301	471	754

FEMP, CROPPED AND CULTIVATED AREAS AND PRODUCTION RECORDS, 1981

FARM NO	CROPPED AREA	CULTIV. AREA	SEED										FEED		LIVESTOCK				DAIRY
			WHEAT	BARLEY	OATS	RYE	RAPE	FLAX	MUSTARD	SWEET CLOVER	ALFALFA	OTHERS	SILAGE	HAY	BEEF CATTLE	FEEDERS	HOGS	LAMBS	MILK
	AC	AC	t	t	t	t	t	t	t	t	t	t	t	t	head	head	head	head	t
1	1005	1145	265	338			129						120			270			
2	1039	1293	726	176	153		102							9	125				
3	1005	1225	476	111		34													
4																			
5	925	1270	685					39											
6	1230	1530	409	157	50		201	79						1092					
7	818	1725	623	251															
8	3640	4693	844	1463			837										500		
9	428	770	119	44	16	25													
10	435	435		65	27									23				125	
11	408	685	204											30					352
12	326	470	59	46										680					
13	725	1315	370	210										39	25	20			
14	1010	2010	689											20			1000		
15	1534	4300	149				96		357										
16	761	1502	593	96															
17	828	1213	514	93	14								23						
18	1525	3200	1161	100		51													
19	60	300				23													
20	1515	2370	627	222									30		143				
21	1110	1489	299	174	18		59						165						483

FEMP CROPPED AND CULTIVATED AREAS AND PRODUCTION RECORDS, 1982

FARM NO.	CROPPED AREA	CULTIVATED AREA	SEED										FEED		LIVESTOCK				DAIRY
			WHEAT	BARLEY	OATS	RYE	RAPE	FLAX	MUSTARD	SWEET CLOVER	ALFALFA	CANARY	SILAGE	HAY	BEEF CATTLE	FEEDERS	HOGS	LAMBS	MILK
	AC	AC	t	t	t	t	t	t	t	t	t	t	t	t	head	head	head	head	
1	1180	1355	520	384			138	64								145			
2	1257	1293	424	318			98							?					
3	850	1225	363	70	25				110										
4																			
5	832	1270	694		35			81											
6	1460	1640	488	123			238	51						305					
7	885	1725	598	419													500		
8	4695	5295	557	3083			874	524											
9	440	770	162	27		20								40				100	
10	435	485			27									360		44			417
11	348	685	234											1736					
12	322	470	150	83							50				20	20			
13	928	1315	481	386										55			1000		
14	1000	2010	463																
15	2659	4285	446	342			177	50	511										
16	741	1502	556	301															
17	517	887	405	122	18								30		38	6			
18	1650	3200	1677	166		47													
19	270	300											354	93	143				
20	1200	2400	596	303	15							61							
21	965	1489	550	327	62								325						480

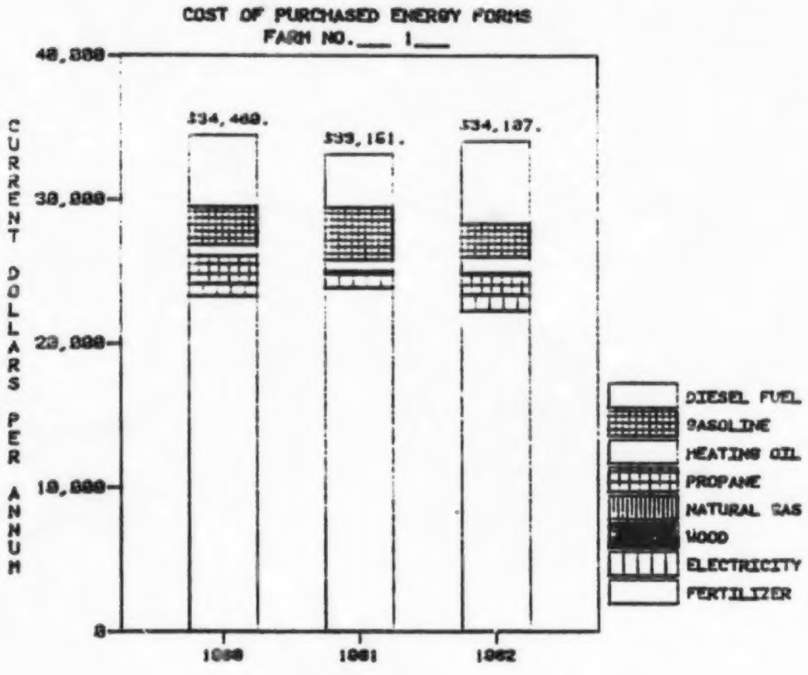
APPENDIX H H

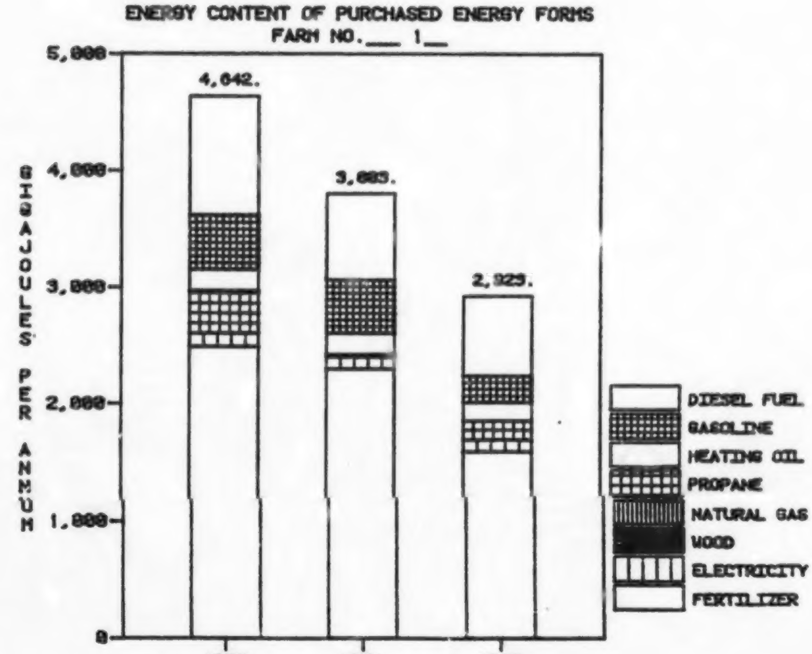
Cost of purchased energy forms

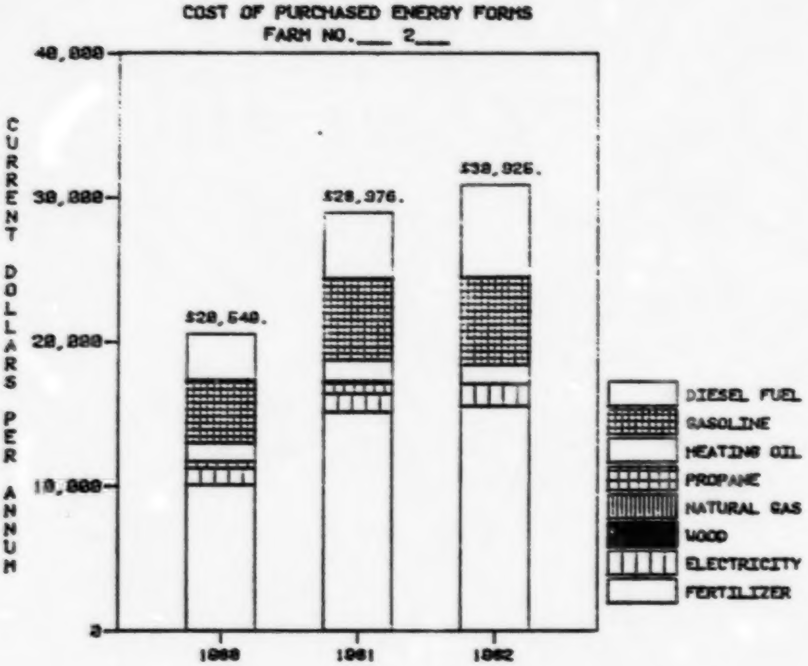
Energy content of purchased energy forms.

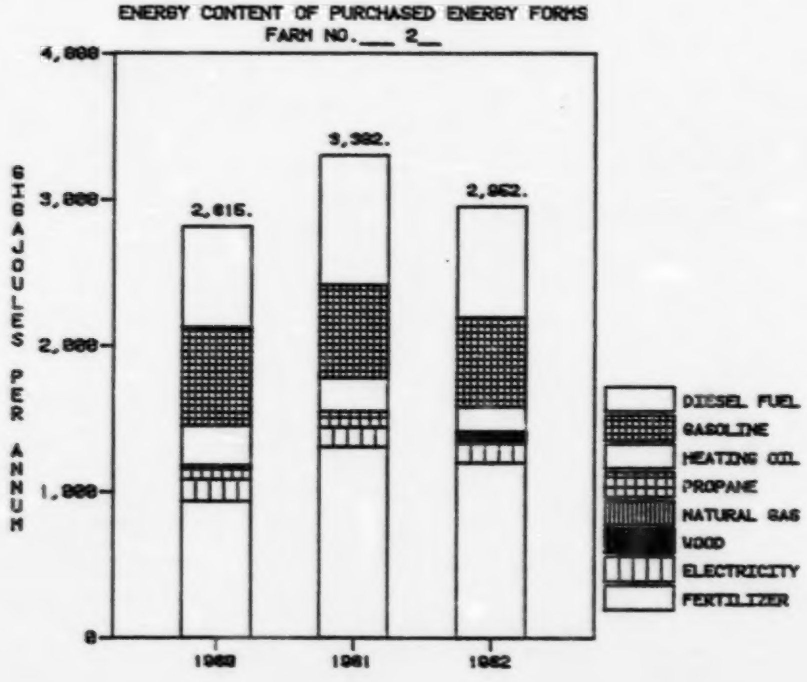
All 21 farms H-1 to H-21

The reader is reminded these are preliminary figures subject to revision. They will be accompanied in a later report with energy use per unit area, etc., since cropped areas may have changed year to year.


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 1___
CURRENT DOLLARS PER ANNUM
40,000
30,000
20,000
10,000
0
$34,460.
$33,161.
$34,137.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 1__
GIGAJOULES PER ANNUM
5,000
4,000
3,000
2,000
1,000
0
4,642.
3,803.
2,923.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 2__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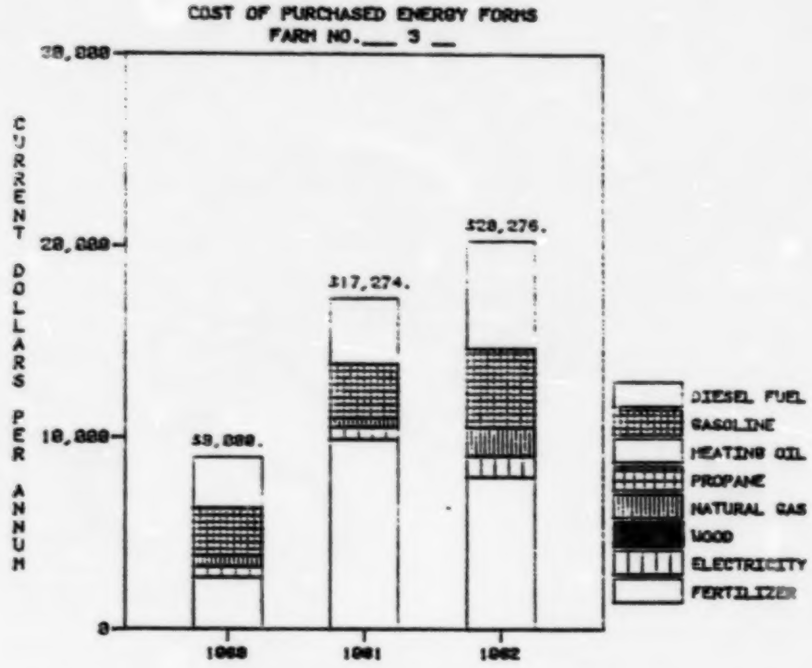
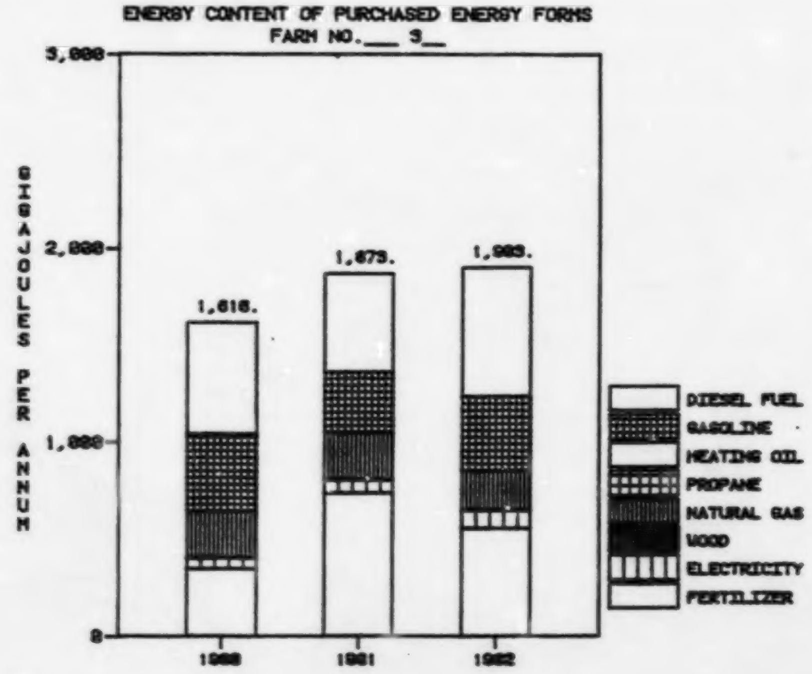
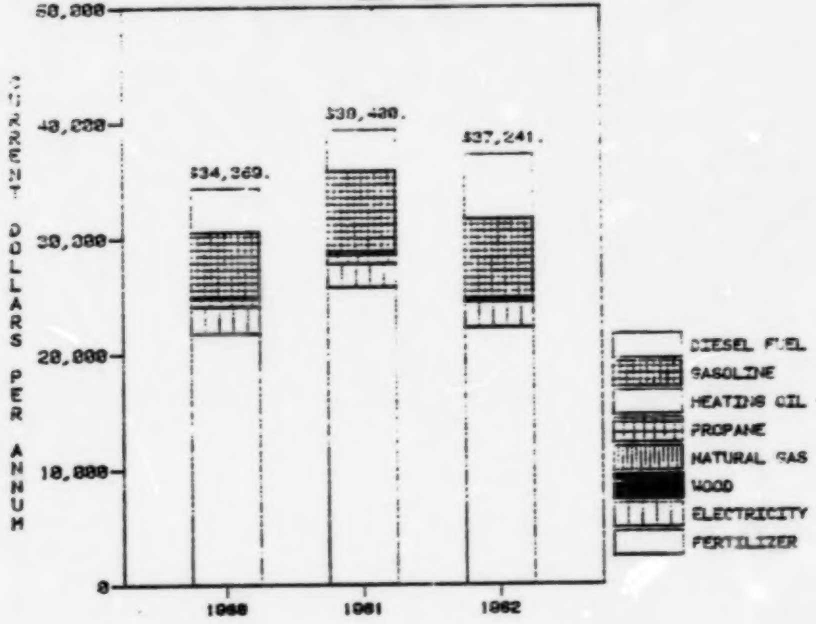
FARM NO.___ 2__

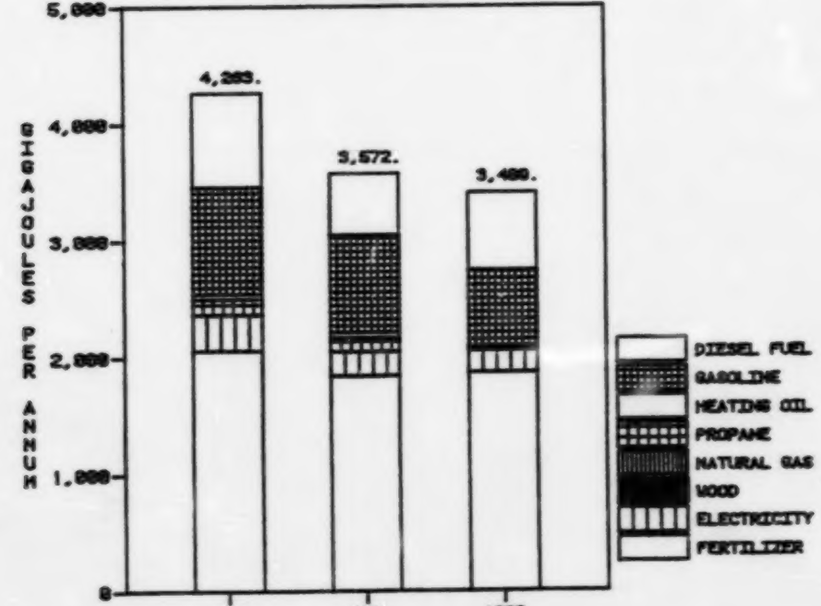

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 3 __

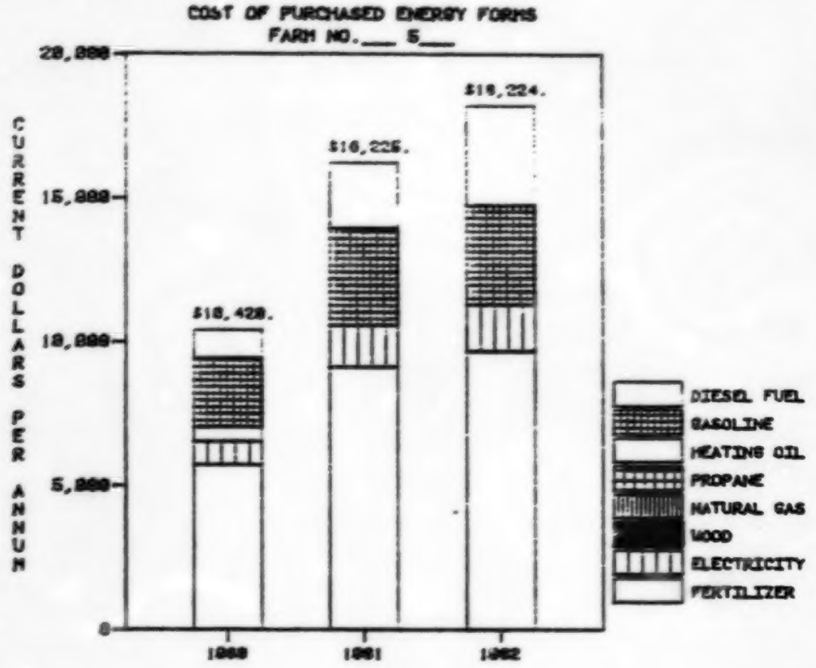

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 3_

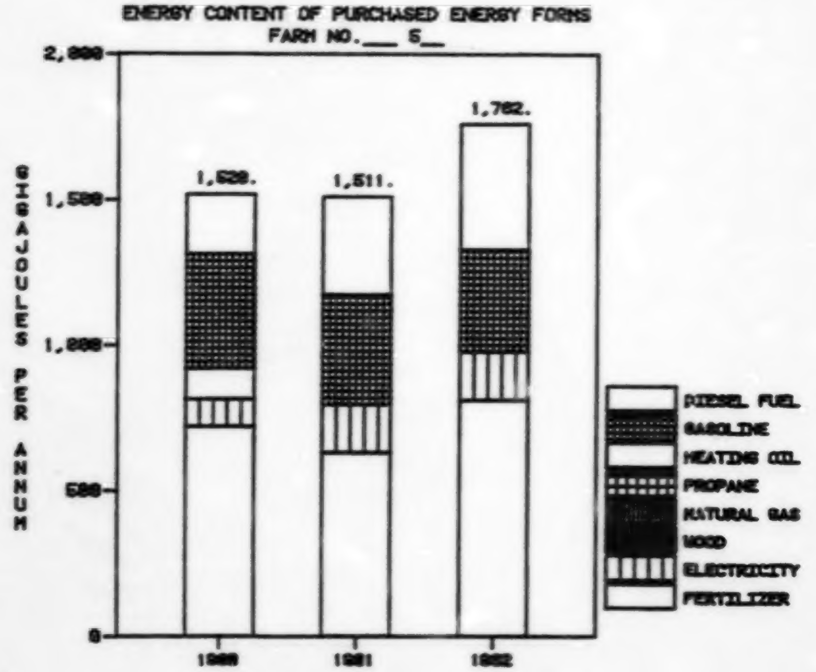
COST OF PURCHASED ENERGY FORMS
FARM NO.___ 4___

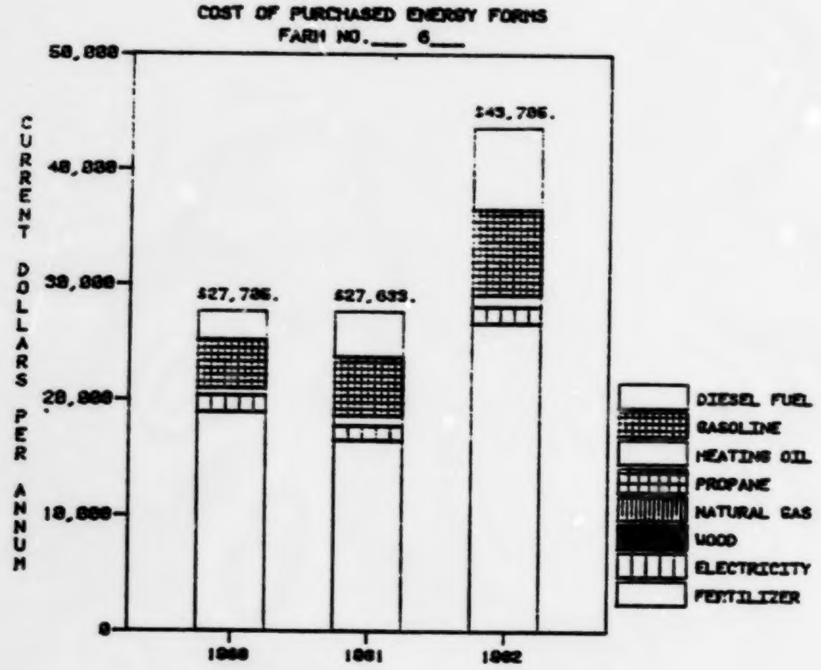


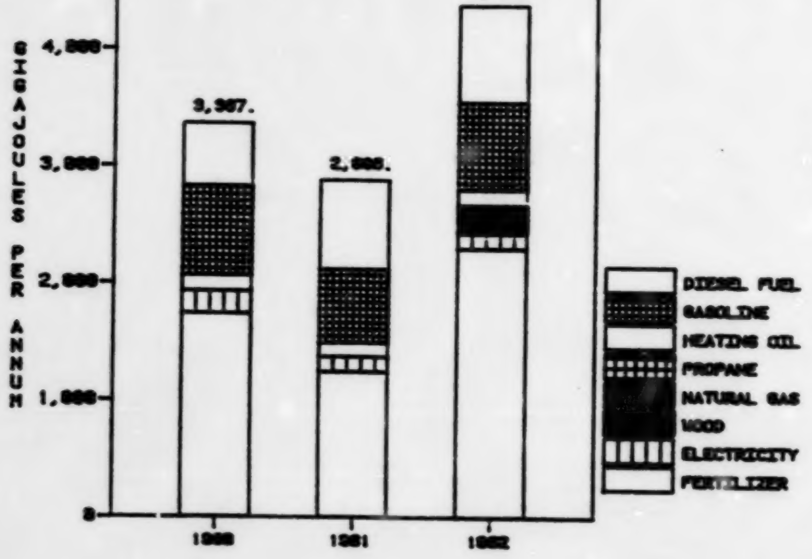
ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 4__

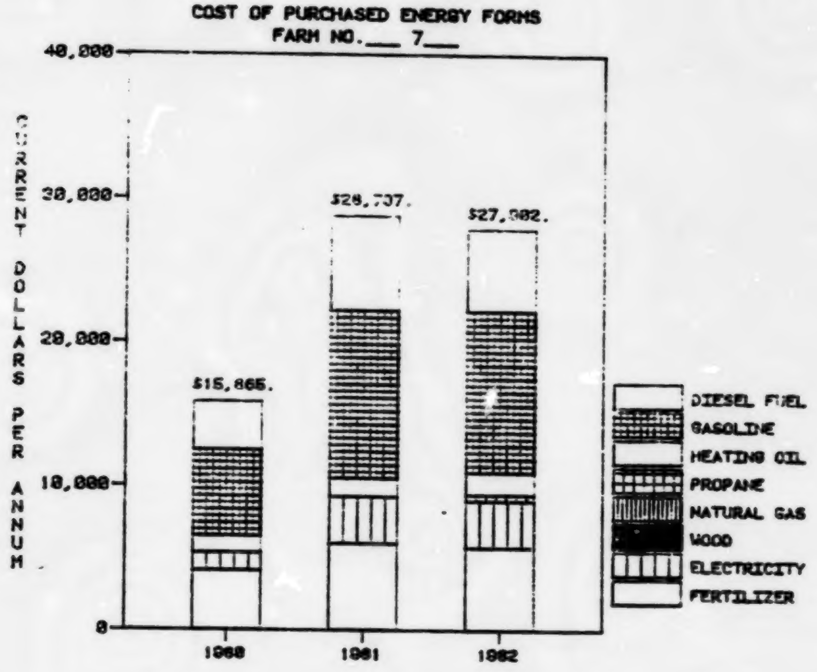


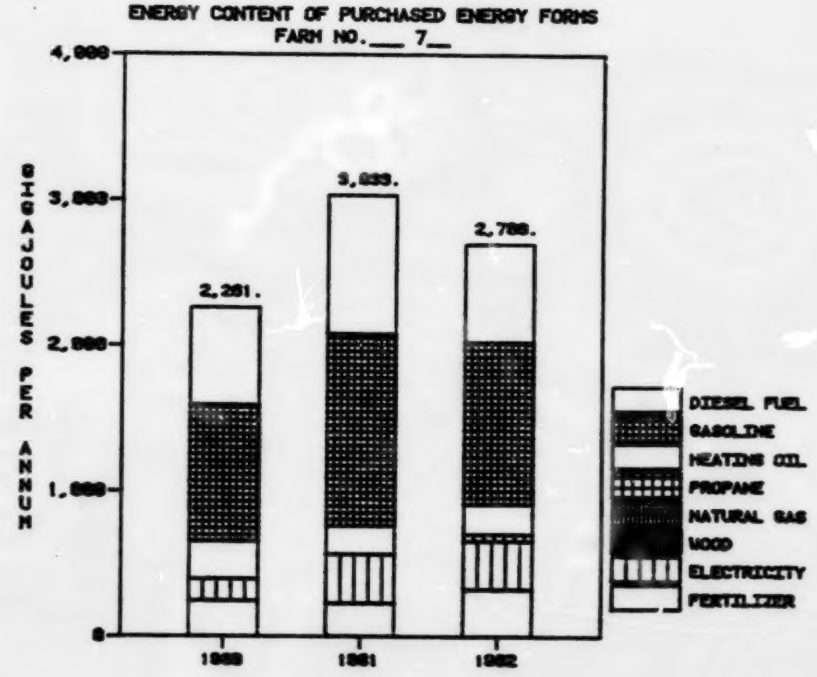

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 5___
CURRENT DOLLARS PER ANNUM
20,000
15,000
10,000
5,000
0
$10,420.
$16,225.
$18,224.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 5__
GIGAJOULES PER ANNUM
2,000
1,500
1,000
500
0
1,520.
1,511.
1,762.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

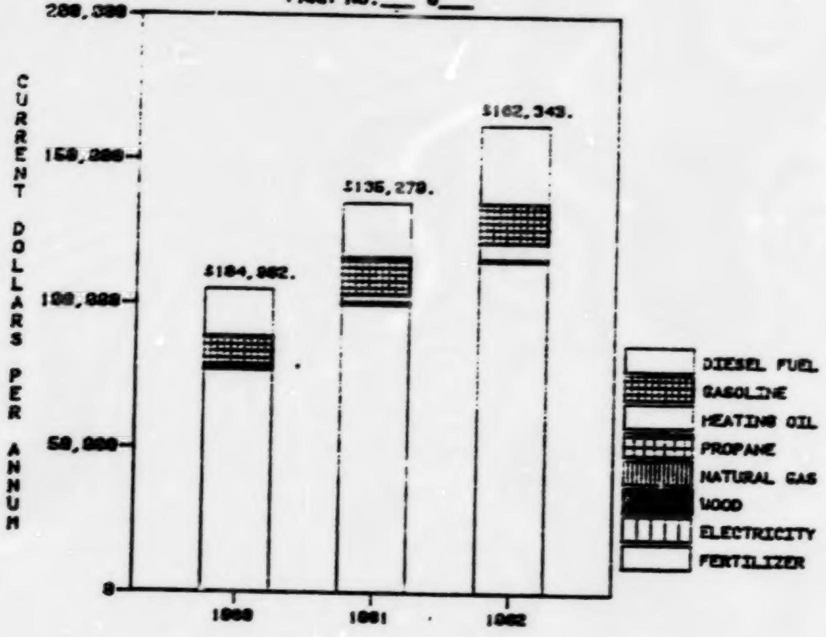

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 6___
CURRENT DOLLARS PER ANNUM
50,000
40,000
30,000
20,000
10,000
0
$27,786.
$27,633.
$43,786.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 6__
GIGAJOULES PER ANNUM
5,000
4,000
3,000
2,000
1,000
0
3,367.
2,888.
4,368.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

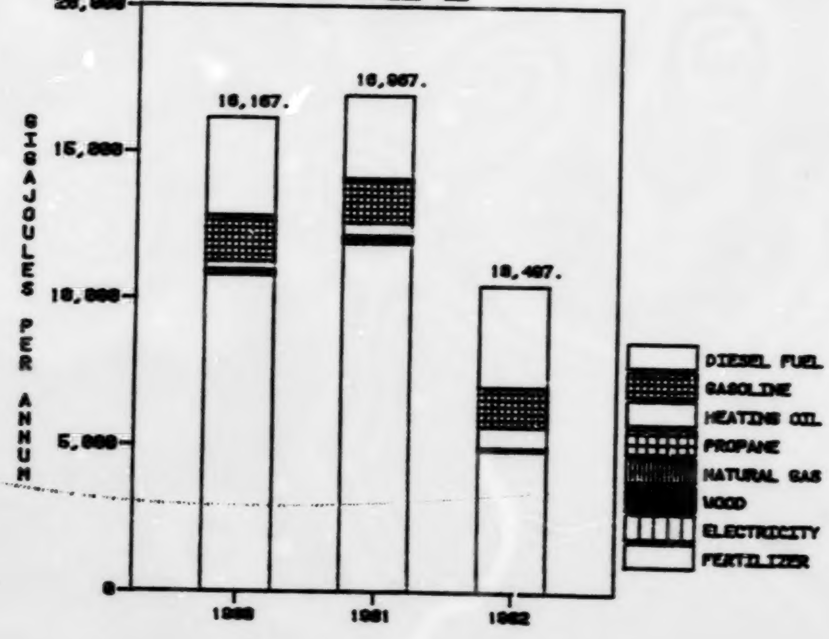

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 7___

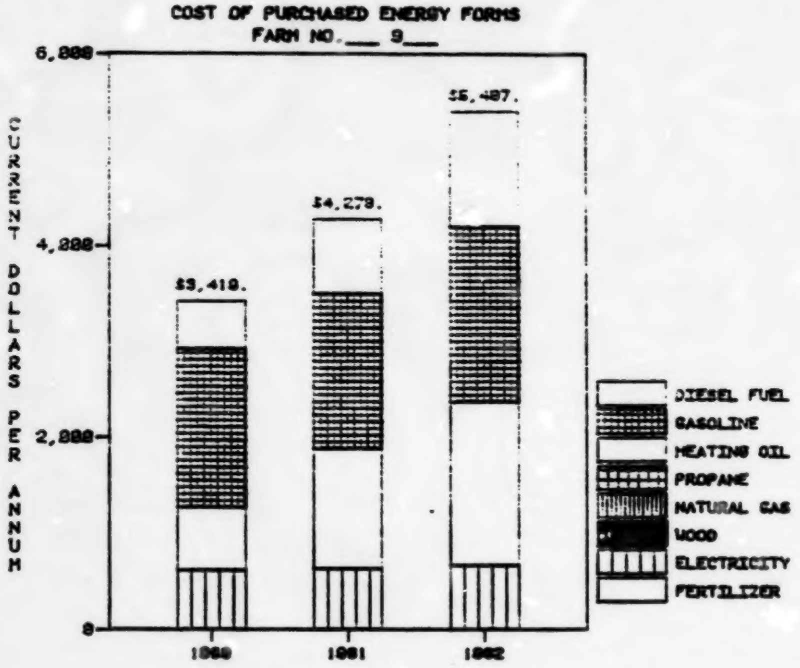

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 7__

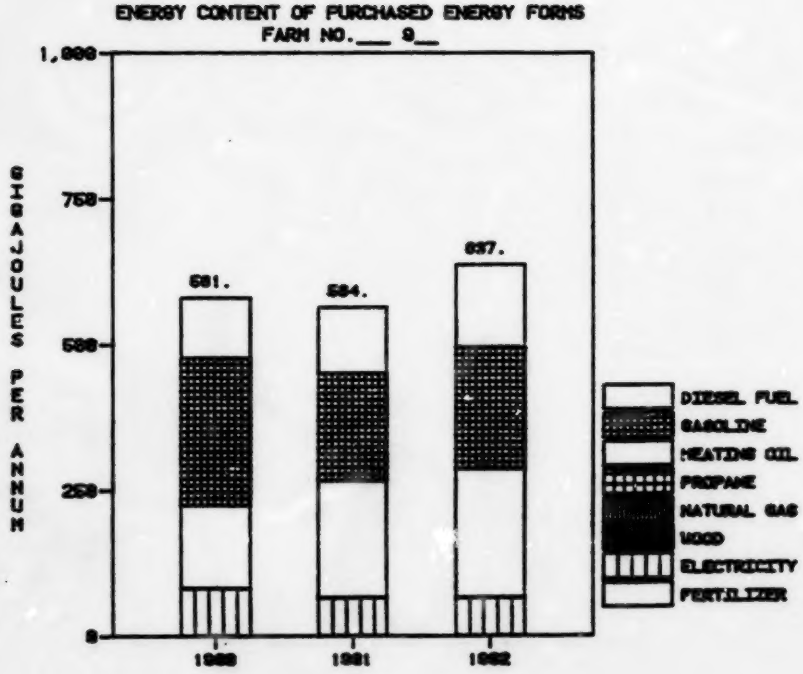
COST OF PURCHASED ENERGY FORMS
FARM NO.___ 8__

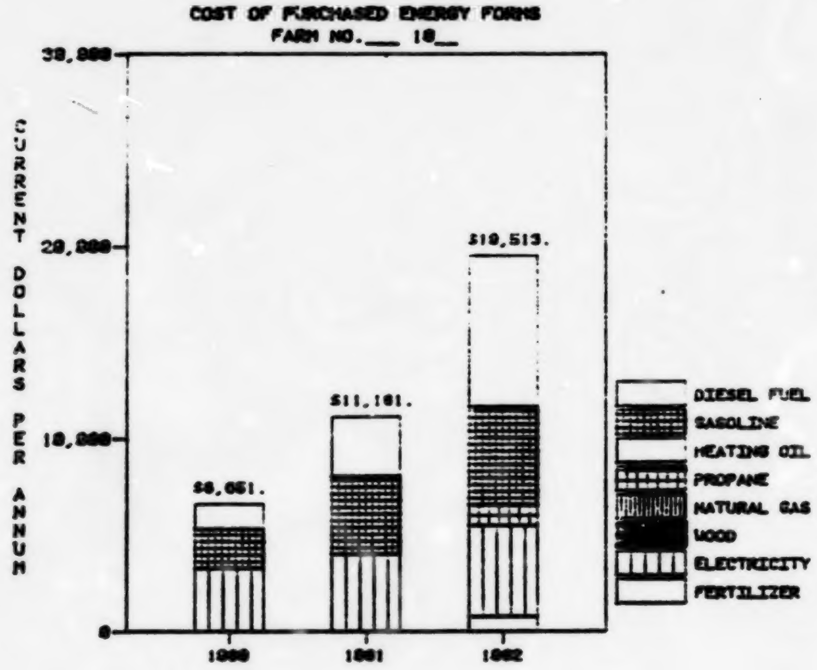


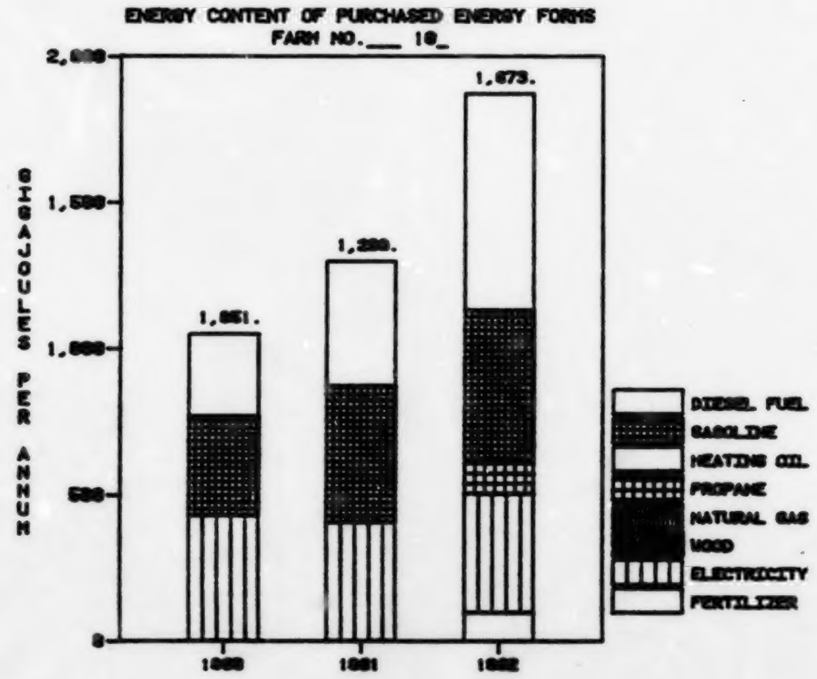
ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 8__

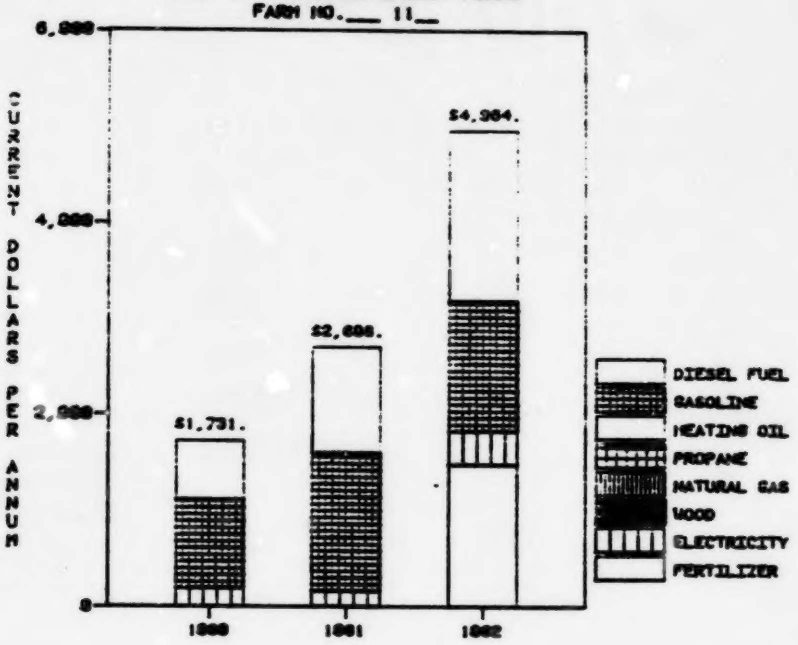



COST OF PURCHASED ENERGY FORMS
FARM NO.___ 9___
CURRENT DOLLARS PER ANNUM
6,000
4,000
2,000
0
$3,418.
$4,278.
$5,407.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

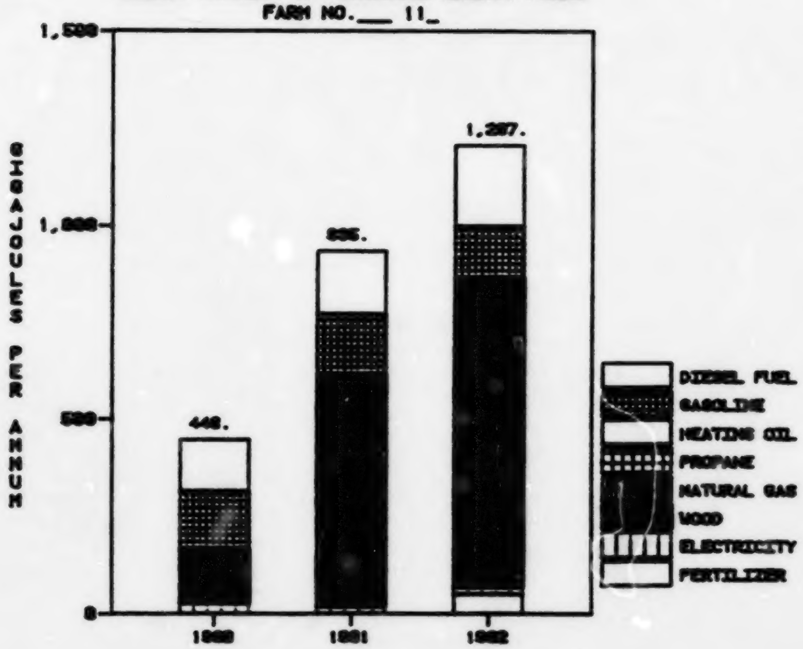

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 9___
GIGAJOULES PER ANNUM
1,000
750
500
250
0
601.
584.
657.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 10__
CURRENT DOLLARS PER ANNUM
30,000
20,000
10,000
0
$6,651.
$11,161.
$19,513.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

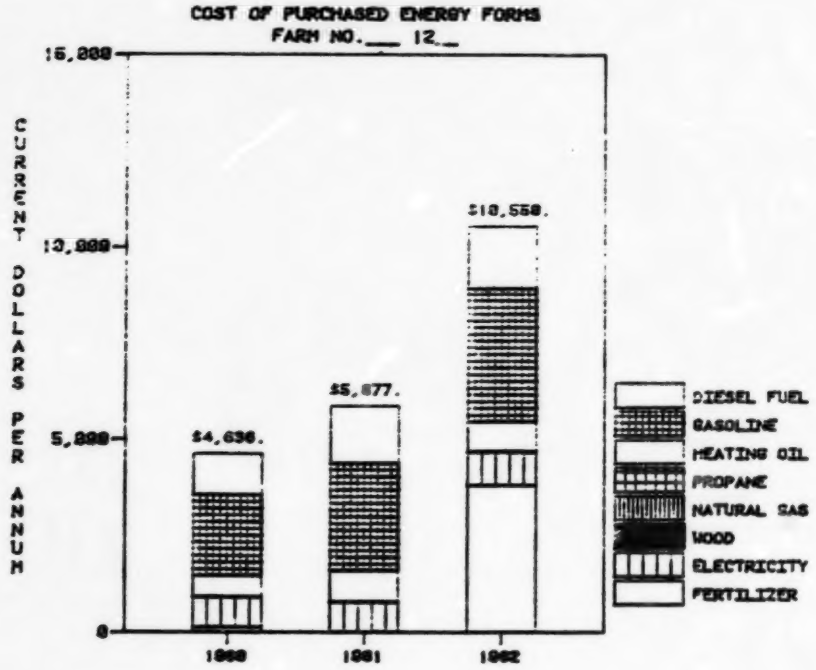

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 10_
GIGAJOULES PER ANNUM
2,000
1,500
1,000
500
0
1,051.
1,288.
1,873.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

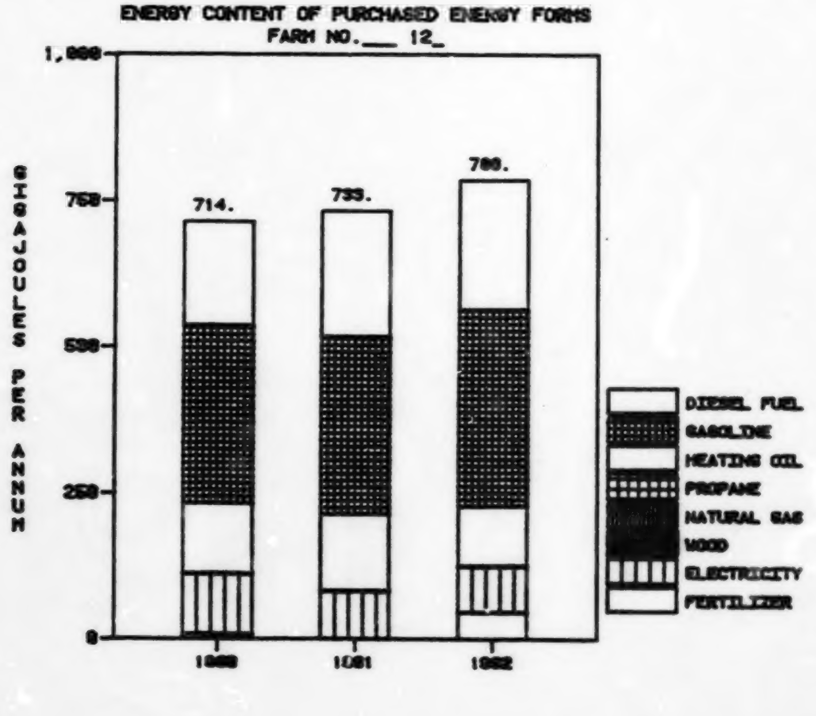


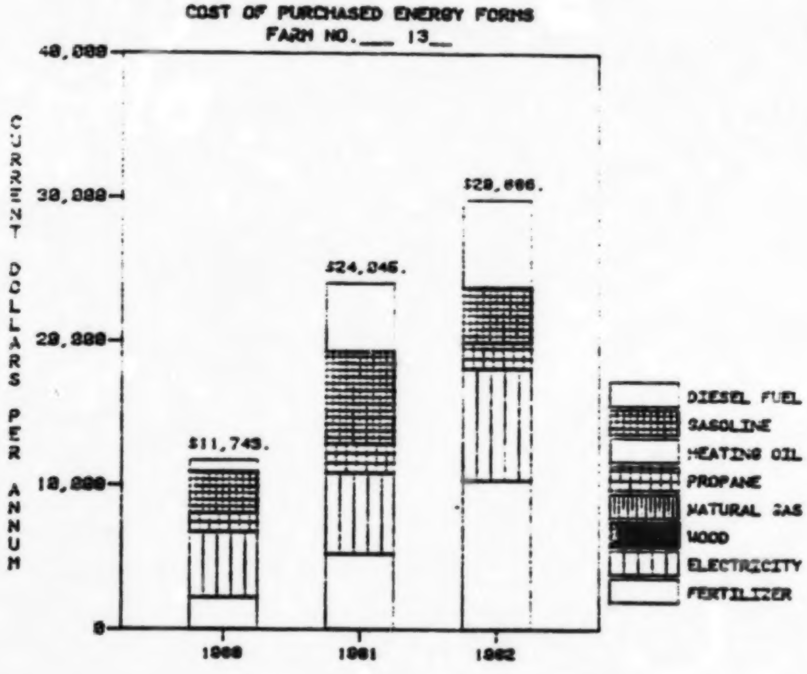
COST OF PURCHASED ENERGY FORMS
FARM NO.___ 11_

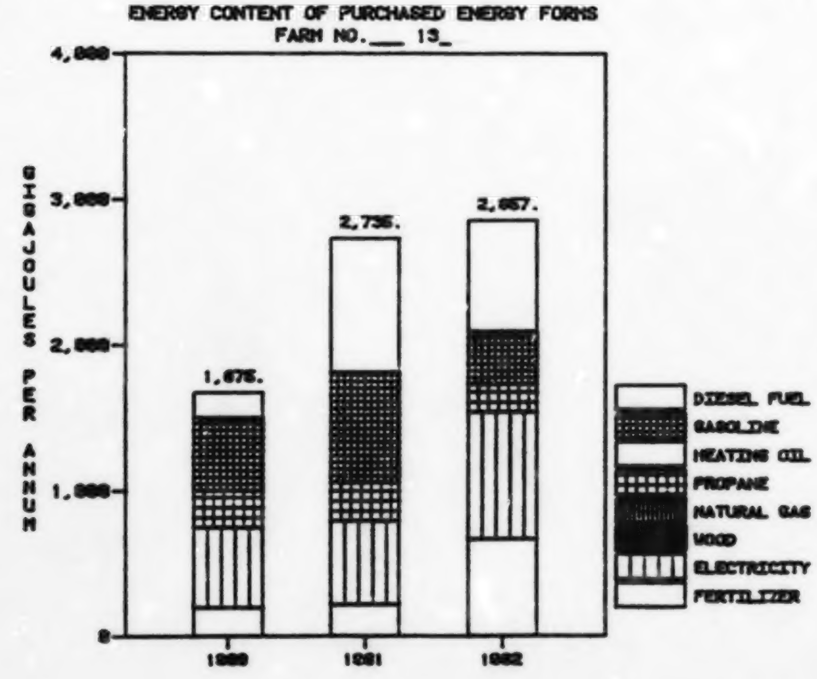


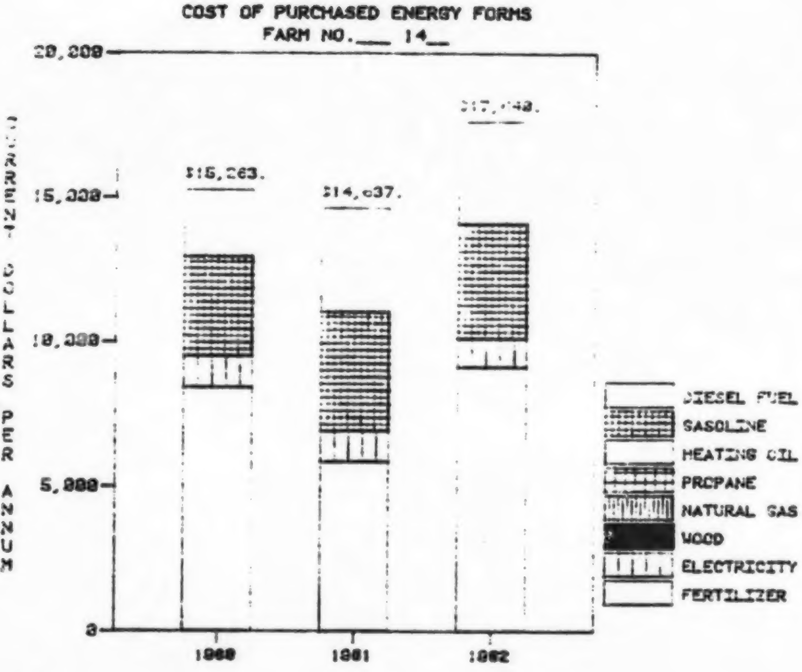
ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 11_

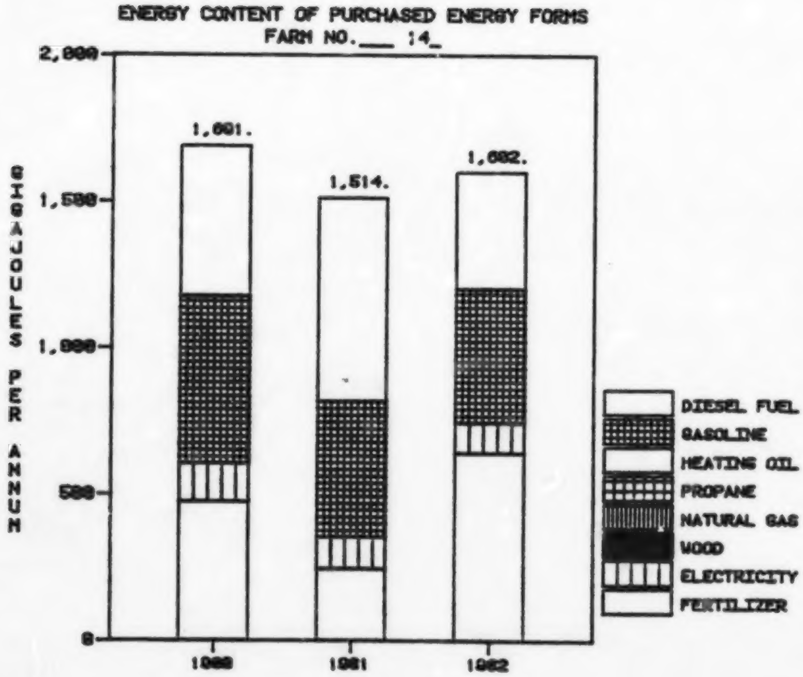

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 12_
CURRENT DOLLARS PER ANNUM
15,000
10,000
5,000
0
$4,636.
$5,877.
$10,550.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

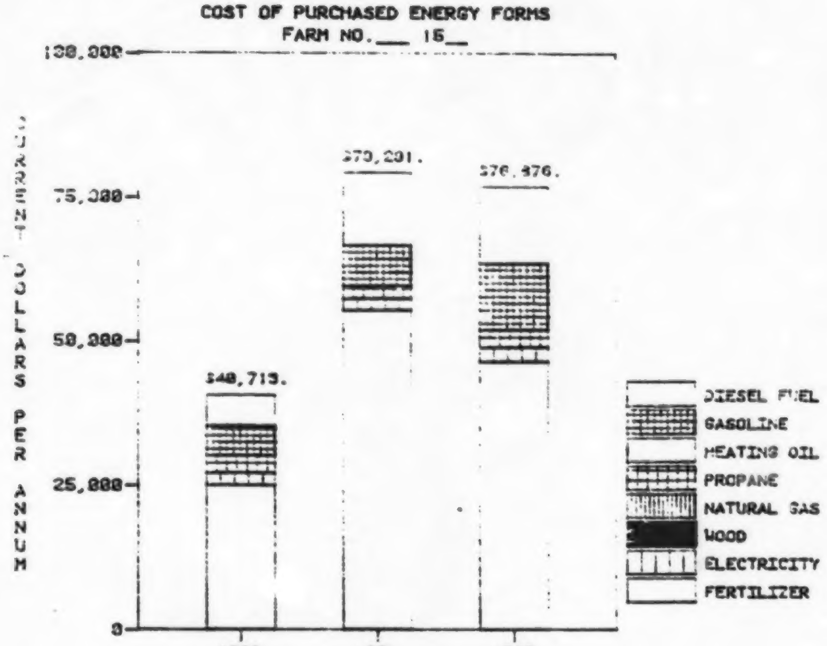

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 12_
GIGAJOULES PER ANNUM
1,000
750
500
250
0
714.
733.
780.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

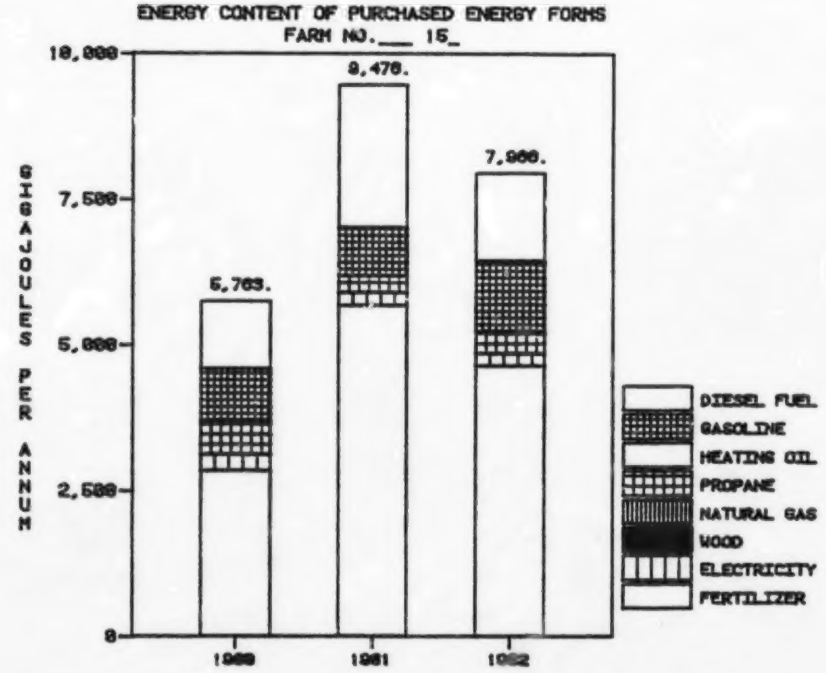

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 13__
CURRENT DOLLARS PER ANNUM
40,000
30,000
20,000
10,000
0
$11,743.
$24,045.
$29,606.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

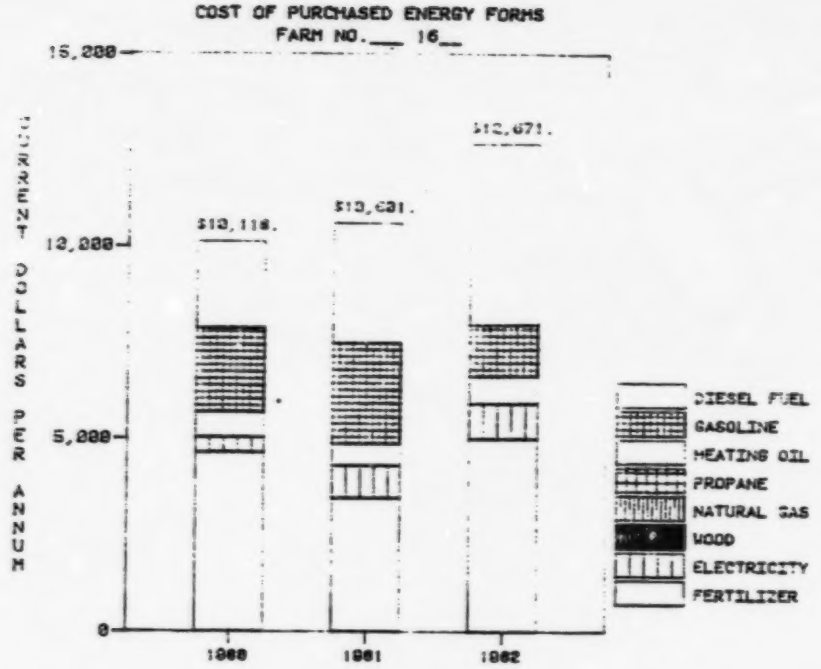

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 13_
GIGAJOULES PER ANNUM
4,000
3,000
2,000
1,000
0
1,675.
2,735.
2,857.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 14__

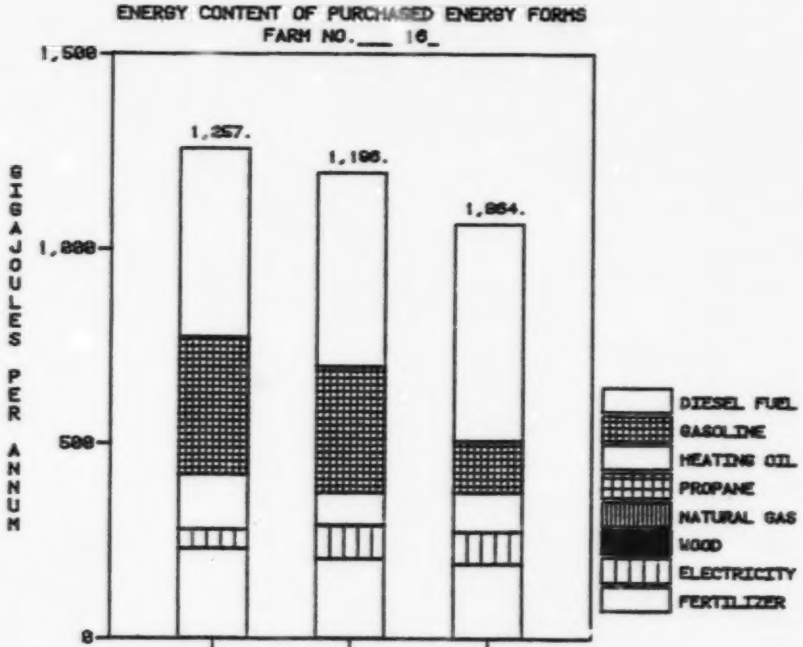

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 14_


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 15_


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 15_

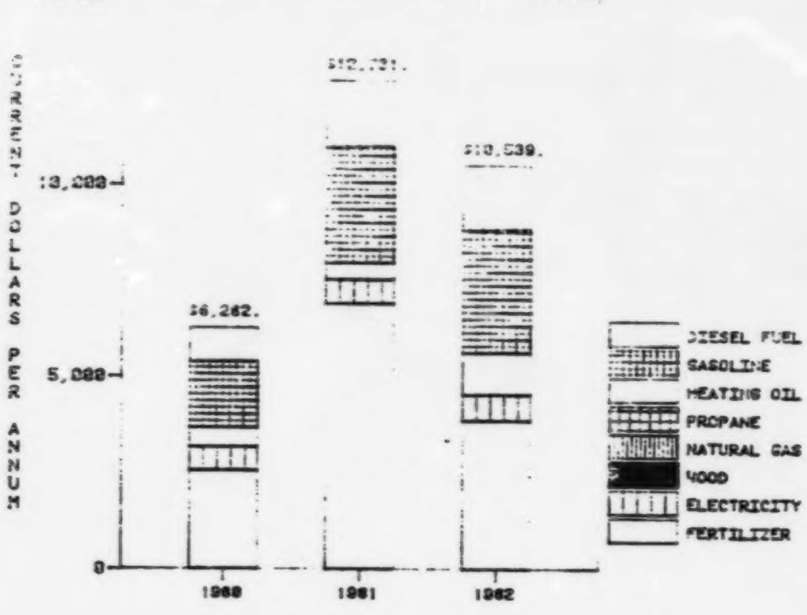


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 16__

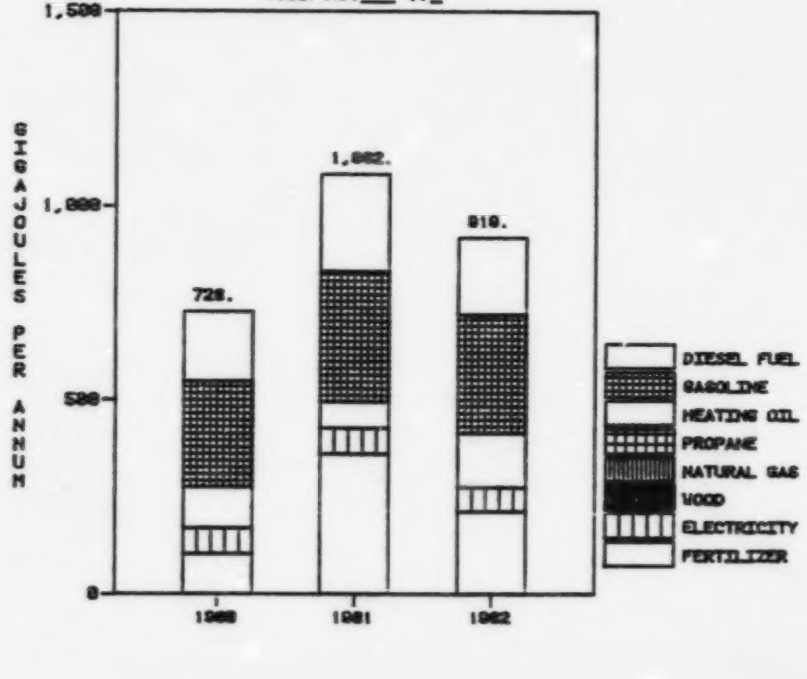


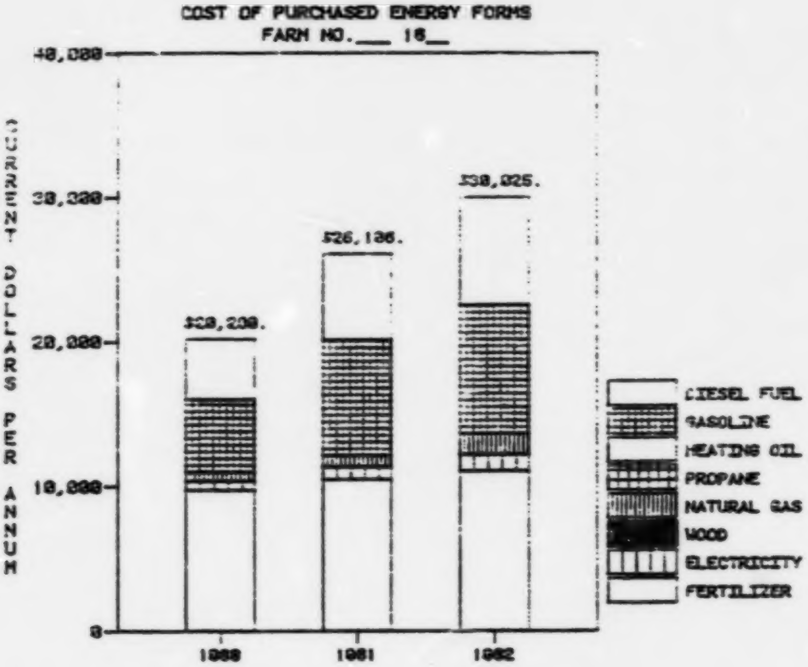
ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 16_

COST OF PURCHASED ENERGY FORMS
FARM NO.___ 17__

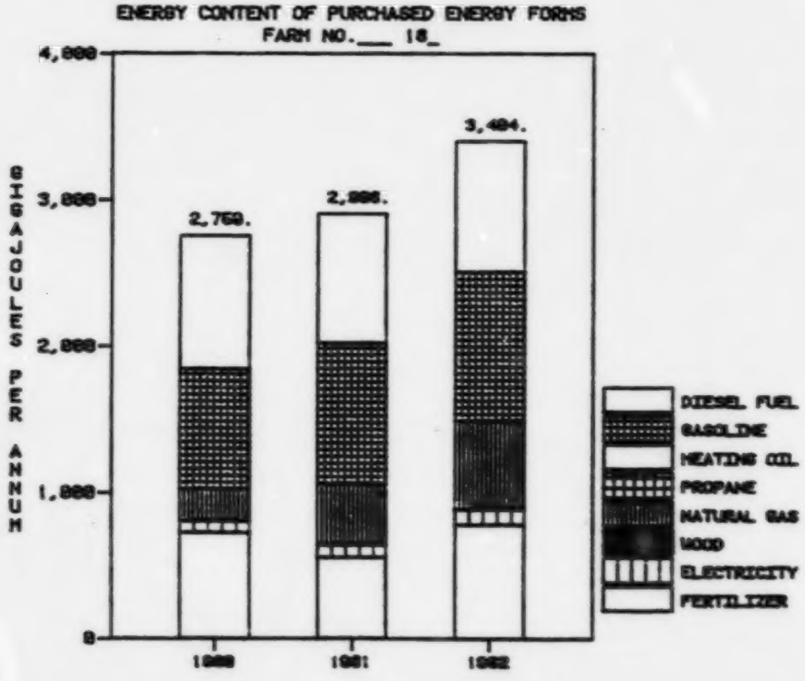


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 17_

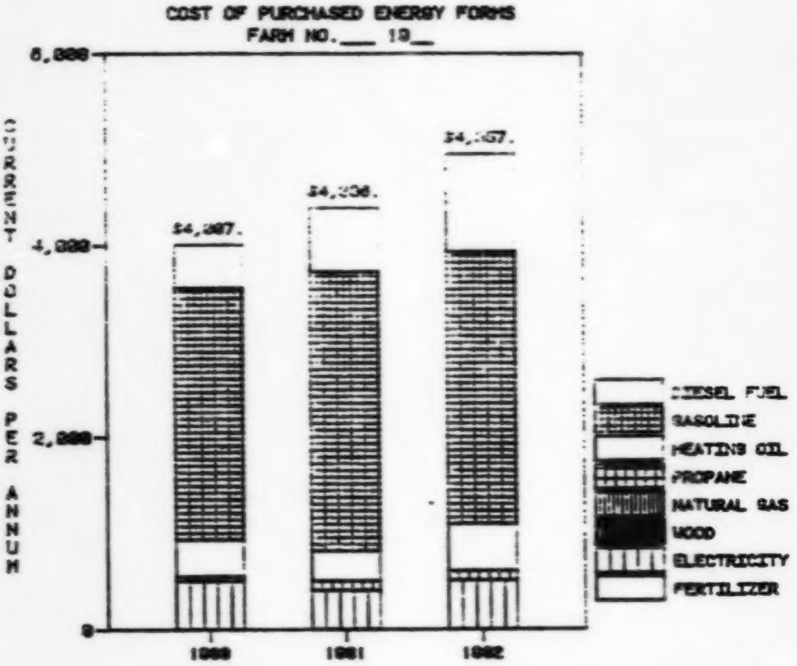


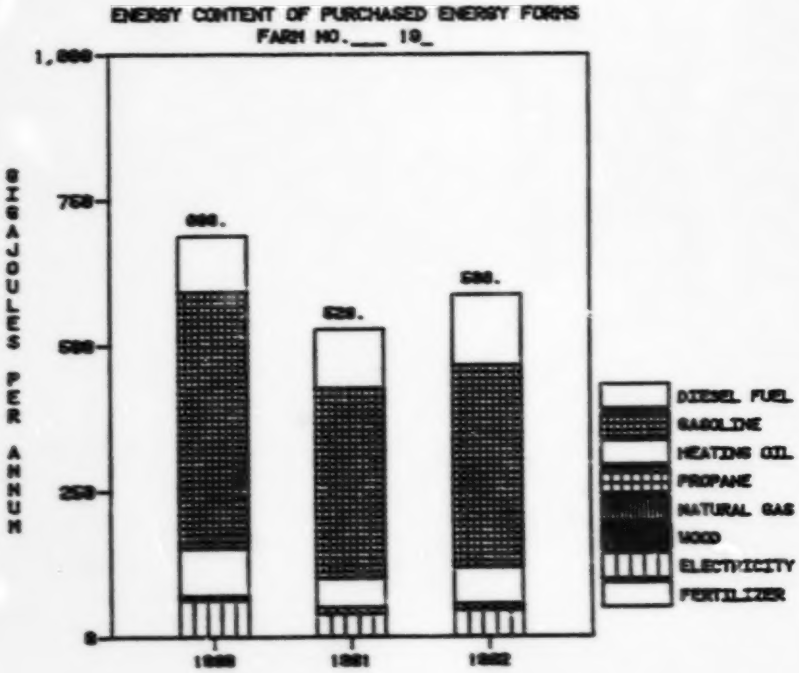


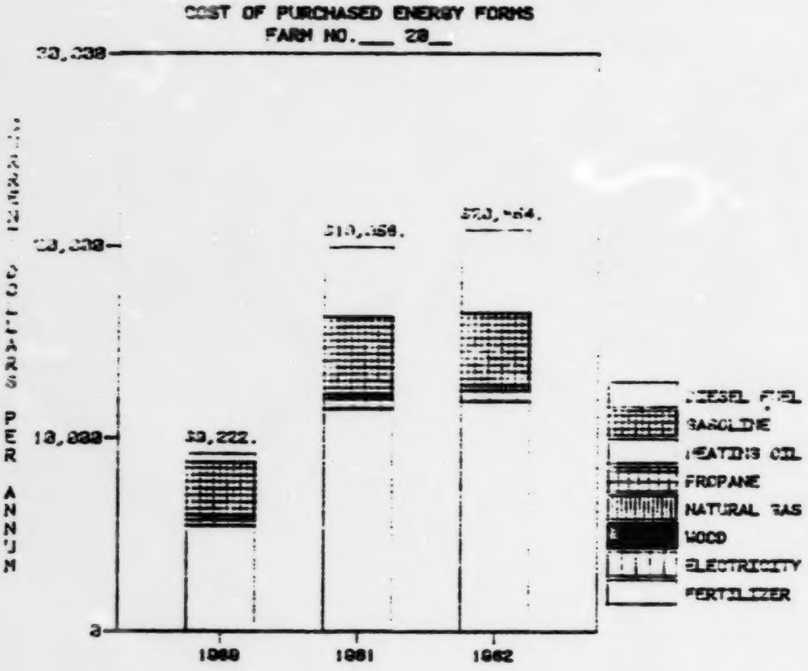
COST OF PURCHASED ENERGY FORMS
FARM NO.___ 18__
CURRENT DOLLARS PER ANNUM
40,000
30,000
20,000
10,000
0
$20,230.
$26,186.
$30,025.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

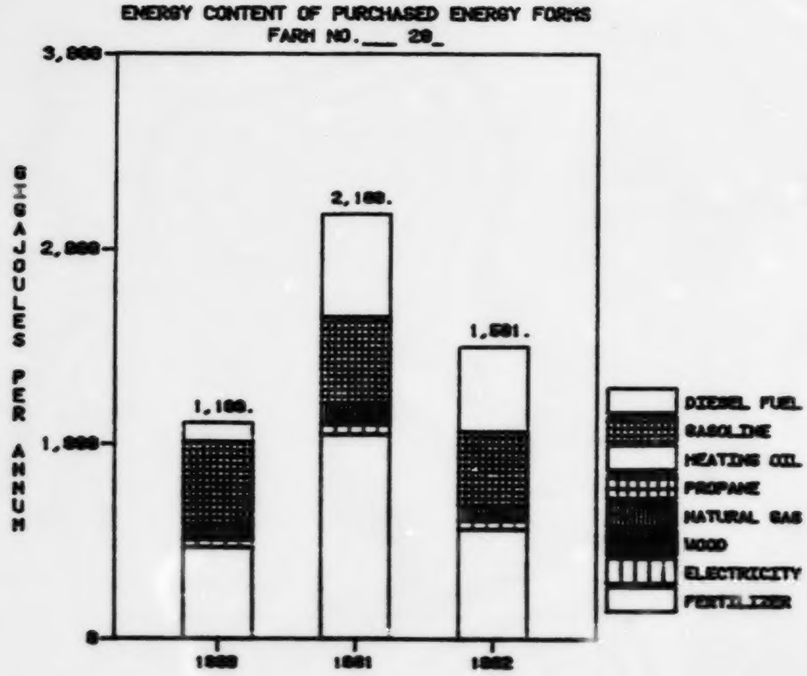


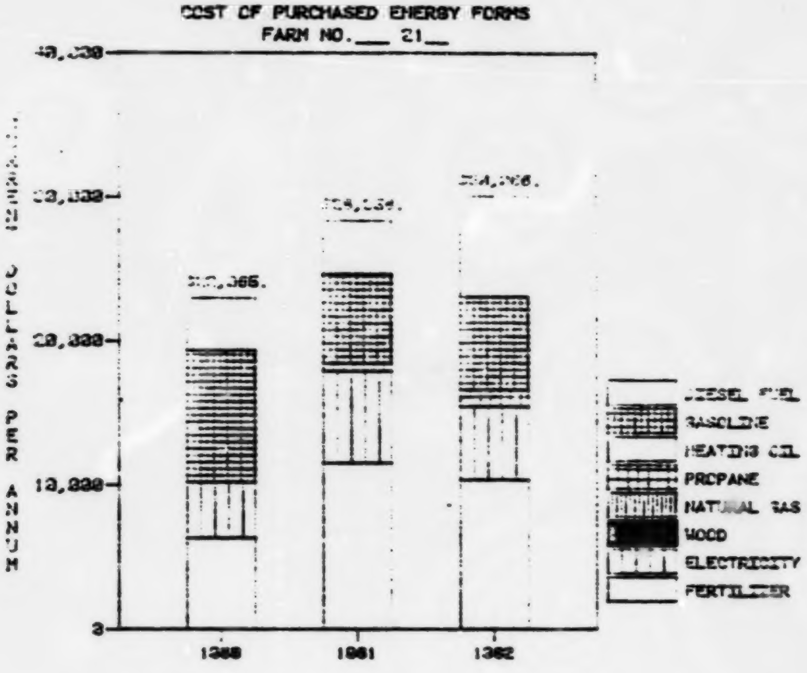
ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 18_
GIGAJOULES PER ANNUM
4,000
3,000
2,000
1,000
0
2,760.
2,888.
3,404.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 19_
CURRENT DOLLARS PER ANNUM
6,000
4,000
2,000
0
$4,007.
$4,336.
$4,957.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER

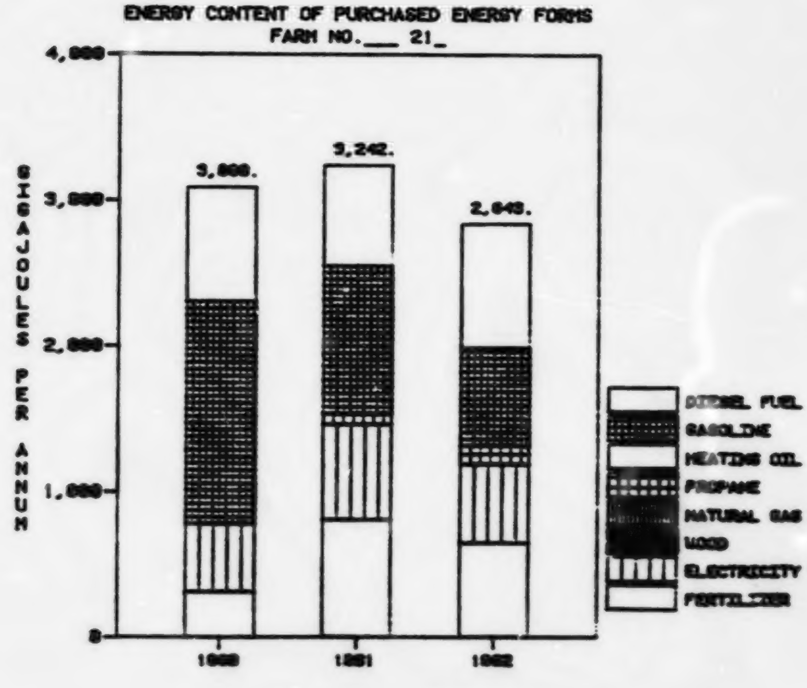

ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 19_
GIGAJOULES PER ANNUM
1,000
750
500
250
0
680.
530.
600.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


COST OF PURCHASED ENERGY FORMS
FARM NO.___ 20_
30,000
20,000
10,000
0
CURRENT DOLLARS PER ANNUM
$9,222.
$19,358.
$20,464.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER


ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 20_
3,000
2,000
1,000
0
GIGAJOULES PER ANNUM
1,100.
2,180.
1,501.
1980
1981
1982
DIESEL FUEL
GASOLINE
HEATING OIL
PROPANE
NATURAL GAS
WOOD
ELECTRICITY
FERTILIZER



COST OF PURCHASED ENERGY FORMS
FARM NO.___ 21__



ENERGY CONTENT OF PURCHASED ENERGY FORMS
FARM NO.___ 21_